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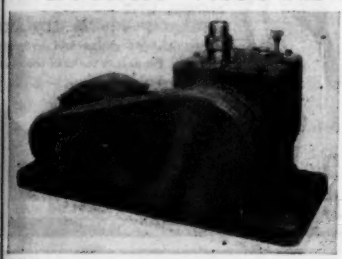

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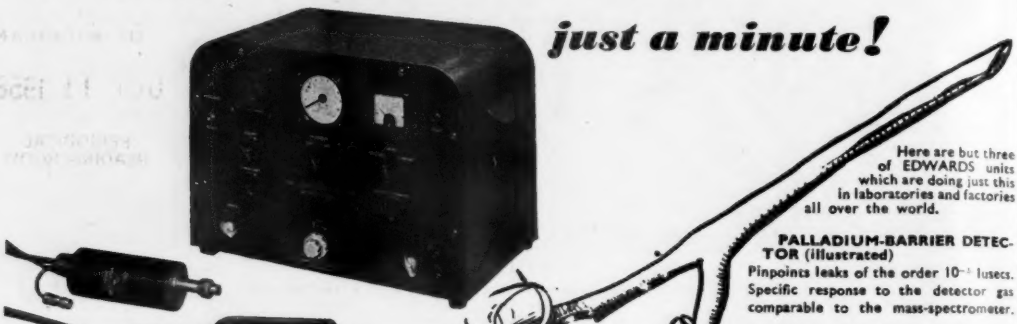

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NATURE

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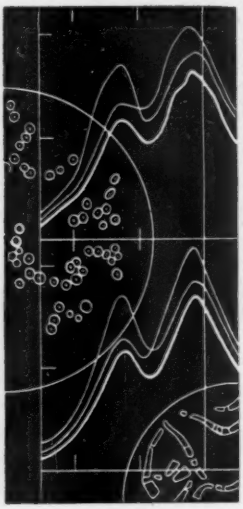

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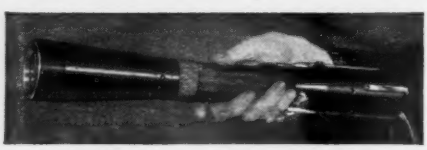

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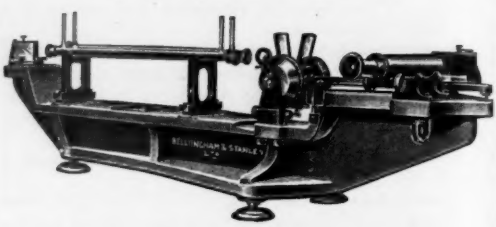

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WORLD POWER IN THE NUCLEAR AGE

WHEN the Chancellor of the Exchequer made his statement about economies in Government expenditure on June 26, he pointed out that the saving of £36·5 million on the defence estimates did not reflect any change in the size or shape of the Armed Services. The savings, of which about £11 million is on the Navy estimates, nearly £17 million on the Army estimates and about £8·75 million on the Air estimates, arise mainly from abandoning or deferring orders, from increasing the use of existing stocks and from expediting the disposal of surplus stocks. Mr. Macmillan referred to the review of defence policy which the Prime Minister had undertaken, and gave the assurance that any major decisions in this field would be taken only after consultation with our allies.

This assurance, which the Prime Minister repeated in the House of Commons on July 23, was needed, for the Government, as two recent debates on scientific research and on technical education have shown, is exposed to a continuous clamour to reduce expenditure on defence quite regardless of the consequences. There is, however, a further principle that needs to be enunciated more clearly at a time when the Government is being pressed with perhaps more zeal than foresight to reduce its expenditure on defence. If we are to get the best results in up-to-date mobile joint defence at the lowest expenditure, it will only be by proceeding hand in hand and step by step with the United States. It is right to point out that Britain's position in the world has changed and that there are limits to the expenditure which she can wisely incur on defence—in terms of manpower, finance or economic resources; and it must be recognized that changes in policy and in disposition can only be made in agreement with our allies.

It is, of course, the uncertainty as to the effect on defence of nuclear warfare that has been responsible for many dubious proposals, and such books as Admiral Elis Biörklund's "International Atomic Policy during a Decade, 1945–1955"* and Prof. E. W. Titterton's "Facing the Atomic Future"†, are invaluable in promoting public understanding of the limitations, as well as of the dangers, of nuclear warfare. Moreover, the *Bulletin of the Atomic Scientists*, which has initiated a symposium on "Science and the Affairs of Man" to continue throughout the tenth anniversary year of the *Bulletin*, after an article in the April issue by R. Aron, discussing the possibility of half a century of limited war, has devoted its May and June issues to a special discussion of science and military strategy.

Admiral Biörklund reviews the decade in two sections, the second of which is concerned essentially with the hydrogen bomb. Then he attempts, in two successive chapters, appreciations of the views of the Western Powers and the Eastern Powers on problems which nuclear weapons present, before considering briefly the technical development of such weapons. His own conclusions as to the possibility of international control are set forth in the following chapters, and the most important of these conclusions is the rejection of the theory, with which he started, that all nuclear weapons should be controlled. He now believes that the manufacture of nuclear weapons could never be effectively controlled, and that they should accordingly be ignored from this point of view and included with conventional armaments. Further, he insists on the importance of restricting control to what really can be controlled, and exercising this control in a way that does not so seriously infringe the autonomy of a State as to increase political uneasiness. Accordingly he suggests that the supervision of mines, transport and laboratories should be relinquished because of the consequent large reduction in the need of permanent control in favour of unexpected flying visits by groups of inspectors with permanent authority and guaranteed freedom of movement and entrance to atomic factories, atomic piles, reactor stations, experimental stations and testing grounds. These visits of inspection, moreover, should extend to any places where there is reason for suspecting that a breach of a treaty may occur or be prepared.

Admiral Biörklund believes that a reasonable control organization could be established, and that international negotiations for an agreement to reduce or stop production of cobalt, large hydrogen and atom bombs and also long-range robots should be made. Success in such a restricted task, which in itself may be difficult enough, would assist, he thinks, in the gradual solution of the other more complicated problems when the situation improves. He would model his control organization on that of Western European Union, making use of the foreign military attachés stationed in the respective countries and appointing atomic attachés. In his view, by stopping the production of the large hydrogen and atomic bombs, though existing stocks are kept for the time being and prohibition of their use is conditional, these weapons become a powerful deterrent against aggression, alike for the Western and the Eastern Powers. Moreover, his proposal, by retaining the present balance of power, on which also an agreement can be based, does not require the Western Powers to give up their essential margin of security.

Admiral Biörklund is convinced that, for the sake of humanity, a solution must be found, and he believes that encouraging the development of nuclear energy for peaceful purposes is likely to decrease world tension and enable the Great Powers to satisfy the demands of peace at the expense of those of war.

While Prof. Titterton's survey is rather more comprehensive than that of Admiral Biörklund, he

* International Atomic Policy During a Decade: an Historical-Political Investigation into the Problem of Atomic Weapons During the Period 1945–55. By Admiral Elis Biörklund. Translated by Albert Read.) Pp. 148. (London: George Allen and Unwin, Ltd., 1956.) 15*s.* net.

† Facing the Atomic Future. By Prof. E. W. Titterton. Pp. xi + 379 + 6 plates. (London: Macmillan and Co., Ltd.; New York: St. Martin's Press, Inc., 1956.) 21*s.* net.

does not attempt to suggest any solution or particular method of control. Until disarmament proposals for weapons of all types, with adequate safeguards of inspection and policing, have been implemented, freedom and survival, he remarks, will depend upon preparedness and strong defence forces. He gives indeed an admirably concise review of Western policy and recent discussions on the control of weapons, and his final two chapters on planning for survival and the steps ahead give a clear indication of the kind of thinking and preparation that are required—thinking of which Mr. Hugh Gaitskell's speech in the House of Commons on July 24 contained more than a hint.

Mr. Gaitskell rightly insisted that whatever new policy we adopt in regard to defence should be hammered out jointly with our friends and allies, and not adopted as each country thinks independently on its own. There is solid truth in his suggestion that the North Atlantic Treaty Organization and the Atlantic Alliance seem unable to decide jointly on the implications of the new situation and that, instead, different countries each say aloud what they expect to do in the circumstances.

The House of Commons debate did not, however, bring out the vital point which Prof. Titterton stresses. It was admitted by Mr. Gaitskell and others that democracies tend to drift apart unless the threat of war is imminent; but the corollary was not faced. If the democracies are to be kept together in the Anglo-American alliance and the North Atlantic Treaty Organization, as Mr. Gaitskell, no less than the Prime Minister, believes they must, more than words are required. A new kind of defence effort is needed in which the public co-operates; and the task of public education that is the first step is only possible if the major political parties co-operate in that task, and cease to make party capital out of even legitimate differences of opinion. Perhaps the biggest problem of defence is that of education—of giving all the people some understanding of the conditions of survival.

Prof. Titterton's book is first and foremost an effort to help in that direction—to help the reader to appreciate those basic facts of the present technological age which every citizen must understand if he or she is to have any influence on the future. That, of course, is also a matter of time, and our second urgent need is accordingly to buy the time in which to achieve the re-orientation of outlook so necessary to a satisfactory solution of the problems of defence. Here Prof. Titterton agrees with Admiral Biörklund as to the need for maintaining world peace through strength, and he considers that with balanced forces at its disposal the West can now meet each type of military threat with an appropriate defence. It is no longer necessary to rely entirely on nuclear bombs, although integration of tactical weapons could greatly strengthen the defence. Thirdly, it is necessary to pursue all possible avenues towards a just settlement of international differences. Mankind can no longer afford the luxury of warfare; fission and fusion weapons have rendered it obsolete as a method of settling international differences. We have still far to go in learning to live together in this changed world; patience, wisdom and human understanding are still needed, and statesmanship of a high order. Nor can we count on rapid progress; but if peace can be preserved through strength and without sacrifice of freedom, the chance of establishing a new order free from fear, and in which full advantage can be reaped from the possibilities of improved living offered by nuclear energy to all men, is not too remote.

No less clearly than Admiral Biörklund and Prof. Titterton, contributors to the symposium on science and the affairs of men in the *Bulletin of the Atomic Scientists* stress the need for seeing clearly the dangers and tasks of the present. Straight thinking and a readiness to prepare and adopt radical solutions for the appropriate moment are essential conditions of survival, and the half-century of limited war which Raymond Aron forecasts could well afford our children the opportunity to achieve a century of peace. Moreover, this clear thinking that is required must be uninhibited and penetrating, considering not simply the place of science in war but also the implications of science for the relations between States in peace as well as in times of tension. Indeed, the symposium itself offers sufficient evidence of the wide differences in opinion that are likely to be met and the slow rate of progress.

Thus, in the discussion on science and military strategy, while several contributors agree that nuclear and thermonuclear weapons are about to become the mainstay of military planning of the major Powers, and that their removal from national arsenals is now unlikely, C. W. Sherwin and W. Amster welcome this approaching state of 'mutual deterrence'. They believe that when the two opposing major Powers are demonstrably capable of destroying each other's economy and population but demonstrably unable to prevent retaliation, stable peace will result. On the contrary, from the same set of facts, Col. R. S. Leghorn and D. Inglis reach the radically different conclusion that the United States and Soviet Russia should arrest the arms race before this ultimate state of mutual deterrence is achieved. They regard an international agreement to stop further nuclear and thermonuclear tests and to halt the development of intercontinental ballistic missiles as our last chance. Stopping at the present level of development of thermonuclear weapons and missiles, they believe, will preserve a situation which will permit a move back towards real disarmament when international relations have improved enough to make extensive international control and inspection feasible. Perhaps the most convincing argument which Leghorn and Inglis develop for this freezing of nuclear weapons is the predicament into which both major Powers could be put by the acquisition of nuclear weapons by several other smaller Powers. The capacity of the two blocks to avoid the outbreak of a major war which neither of them wants may thereby be badly crippled. Furthermore, like Admiral Biörklund's proposals, those of Leghorn and Inglis can be enforced without extensive inspection.

It may be that the ideas advanced by Col. Leghorn and Mr. Inglis have already been judged by official advisers as technically impossible or coming too late; but while differences of opinion between technical and scientific experts are unavoidable, it is not impossible or impracticable to make those differences intelligible to the layman. Indeed, it is an important part of the task of public education that the reasons for such differences should be explained and made known to the public. In the radical revision of defence which the British Government is quite rightly contemplating, it is extremely difficult to make the right decisions and only too easy to make the wrong choice. Moreover, such economies as are possible in concert with our allies cannot do more than enable us to make the best use of our limited resources and avoid placing an intolerable burden on our economy. They can do nothing to make for more comfortable living or lighter taxation, unless we are prepared to abandon all pretence of being a great Power and accept the incalculable political and diplomatic as well as economic consequences. There is no escaping otherwise the enormous and increasing expense of thermonuclear weapons as the deterrent on which we at present propose to rely.

So long as Britain proposes to share in the strategic deterrent, it cannot escape that cost; and the scientist and technologist as such will have some contribution to make towards the wise selection and disposition of our resources for that purpose. They can help also in making clear the implications of alternative policies, both for materials and for scientific man-power; and there are scientific and technical factors which should be taken into account in deciding just what Britain's share in the nuclear deterrent should be. Probably, however, their most important contribution will be to the task of public education to which Prof. Titterton refers. They can help to see that misleading statements are duly corrected—that the Chancellor of the Exchequer's suggestion that we might come down to an expenditure of only 5 per cent of our national income on defence is seen as an impossibility. Beyond that, they can play their part, as the Geneva Conference on the Peaceful Use of Atomic Energy last year has demonstrated, in promoting greater understanding and unity across national frontiers.

If we can gain time for this task of education, it may well be one of the most important ways in which science can contribute to world peace. In an article on "Science as a Force of Unity among Men" contributed to the *Bulletin of the Atomic Scientists* of June, Pierre Auger, arguing that the great task of our time is to create unity among the peoples of the world, refers to the great human value of such international institutions as the European Council of Nuclear Research. Developments along such lines, he believes, would greatly assist unity and understanding.

While British scientists should not neglect their opportunities for contributing to international understanding in such ways, in the field of defence their main responsibility at present is in the task of promoting the formation of a sound public opinion; above all in regard to the implications of nuclear weapons and particularly for our research effort and the distribution of scientific and technical man-power. Even the radical change in strategy and tactics which is involved in any fundamental revision of defence policy in Britain has implications for scientific and technical man-power which need to be considered and explained. If the right decisions are to be reached, it is important that there should be as much informed discussion as possible. If, when the decisions are taken, they are to be firmly executed and faith maintained with our allies, it will be no less important that all that is involved is clearly and fully explained to the public, so that policy enjoys the assured support of an informed and understanding public opinion no matter what political party may be in power.

THE BRITISH FLORA IN RETROSPECT

The History of the British Flora

A Factual Basis for Phytogeography. By Dr. H. Godwin. Pp. viii+384+26 plates. (Cambridge: At the University Press, 1956.) 90*s*. net.

THE foundations of the history of the British flora were well laid when Clement Reid at the end of the nineteenth century published his pioneer work on "The Origin of the British Flora", largely based on seed material which he and his wife collected and identified. But the frequency of such macroscopic specimens as seeds and leaves is poverty compared with the wealth of pollen grains often preserved; it was Von Post who so ably demonstrated this to be a most valuable means of tracing vegetational changes, and his methods were applied in Britain by Woodhead and Erdtman in the middle and late 1920's. From the middle 1930's onwards, Dr. H. Godwin and his associates have exploited this field of study, and the present work is a valuable summary of the rich harvest of their results.

The resistance of pollen grains to decay and their generic and even specific distinguishability render their occurrence of great importance, provided adequate caution is used for guarding against the obvious sources of error. Undoubtedly the most important part of this book is the section devoted to the records of species and genera, which occupy more than half the text and which deal with more than five hundred kinds of plants, fully documented as to the sites from which they have been obtained. Here, for example, the reader can assess the extent of the present evidence for the national status of box, the ancient occurrence of *Lythrum hyssopifolium* or the shrunken distribution of *Polemonium coeruleum*; or again, by reference to *Trapa natans* and *Naias flexilis*, he can envisage some of the evidence for a post-glacial climatic amelioration leading to a climatic optimum in the first half of the Atlantic period.

The text begins with an account of the collection and identification of plant remains, followed by a consideration of Quaternary chronology in which the author provides a tentative scheme of the main vegetational changes from 12,000 B.C. to the present time. Following the plant records already referred

to, the author discusses what is termed the pattern of change in the British flora. Here it is apparent, as the author is at pains to emphasize, that, despite the accreted knowledge of the past quarter of a century, there remains a wealth of ignorance and speculative conjecture which only the assiduous collection of further material can remove or justify.

The interplay of climatic, edaphic and historical factors can only be significantly assessed in the light of a far more detailed knowledge than we at present possess of the autecology of individual species and, in particular, of their major physiological responses; never forgetting that, within the same morphological taxon, races of widely differing physiological response may occur, such as the differing photoperiodic response of strains of *Arabidopsis* or alternative reproductive tolerance, as where a species in one climatic complex reproduces by seed and in another by vegetative exuberance.

On the path of his own speciality, we can follow Dr. Godwin with confidence; but when he strays towards the edge his guidance is less reliable. In common with some other phytogeographers, Dr. Godwin appears loth to admit that plant dispersal, although naturally varying in effectiveness with the species and conditions of the habitat, is not infrequently highly successful—perhaps because this introduces an element of uncertainty that is difficult to assess. Thus Dr. Godwin naïvely accepts the increased occurrences of *Himantoglossum* in Britain between the two World Wars as possibly related to climatic conditions and ignores the fact that after the First World War there was a considerable importation of lizard orchids for garden culture. That the plants often seeded freely is a fact, and millions of seeds must have been widely dispersed. The importation is believed to have ceased before the Second World War, and no additional records have in recent years been added. This may be mere coincidence; but on present evidence the facts are at least equivocal. Again, on p. 342 Dr. Godwin states that it can scarcely be doubted that *Bromus secalinus* is a weed, although chess in primitive times, as to-day, was probably cultivated as a crop plant.

But if here and there one feels that judgments have been made on too narrow a consideration of the relevant facts, one cannot doubt that this book is not only a major contribution to this topic, but will also serve as a valuable foundation upon which future work can be based. E. J. Salisbury

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TECHNIQUES AND THEORY OF MOLECULAR BEAMS

Molecular Beams

By Prof. Norman F. Ramsey. (International Series of Monographs on Physics.) Pp. xii+466. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 75*s*. net.

THERE can have been no more elegant developments of technique in recent years in any field of physics than those that have taken place in the study of beams of neutral atoms and molecules. By combining the techniques of radio-frequency and ultra-high-frequency oscillations with those developed earlier for the production and detection of molecular beams, Rabi and his associates introduced the molecular-beam resonance method which has made possible the measurement of magnetic and electric moments, both of nuclei and of molecules, with an astonishing precision.

In nuclear physics such measurements have been of great significance in the development of current ideas of nuclear structure. In molecular physics they have enabled precise determinations of molecular constants and have contributed to the study of polymerization. But perhaps most important of all has been the contribution of measurements of this kind to the deeper understanding of electron and radiation physics. Precise determinations of atomic magnetic moments established the existence of an anomaly in the magnetic moment of the electron. Using a rather different beam resonance method, Lamb and Rutherford, in their now classical experiment, established the splitting of the $2s_{1/2}$ and $2p_{1/2}$ atomic states of hydrogen and measured it with great accuracy. The remarkable agreement between the calculated values of the anomalous electron magnetic moment and the Lamb–Rutherford shift with the measured values constitutes to-day the most impressive evidence in support of quantum electrodynamical theory and of the essential validity of the mass renormalization methods used in its application to specific calculations.

In this book the techniques of these and many other types of experiment using molecular beams, together with the results obtained and their significance, are described for the first time in a full-length monograph by Prof. N. F. Ramsey, who has himself contributed very much in this field. One has the impression that the author is equally at home whether discussing the finer points of experimental detail or the theoretical bases necessary for the interpretation of the experiments.

Although most of the volume is devoted to the measurement of magnetic and electrical moments, a short early chapter on gas kinetics serves as a reminder that molecular-beam techniques have a considerable importance also in low-energy atomic and molecular physics and in the physics of surfaces. This is followed by a chapter in which the basic expressions for the multipole expansion of the electrostatic and magnetic interactions are set out in a clear and useful form. Then, after a chapter on measurements of the earlier Stern–Gerlach type, most of the remainder of the book is devoted to a comprehensive discussion of magnetic and electric molecular-beam resonance methods and their application to the study of nuclear magnetic moments and electric quadrupole moments, the radio-frequency spectroscopy of molecules, the anomaly in the magnetic moment of the electron and the Lamb–Rutherford shift. The interesting possibilities of the development of an atomic-beam clock capable of measuring time-intervals with an accuracy of 1 in 10^{13} and of a molecular microwave amplifier (the 'maser') are discussed briefly. The last two chapters are devoted to the principles used in the design of molecular-beam experiments and to a detailed discussion of the experimental techniques of molecular-beam physics.

The large number of carefully chosen figures, the comprehensive tables of data on nuclear moments and molecular constants obtained using molecular-beam methods, and the useful set of appendixes, add greatly to the value of the book, which is likely to remain the standard work in this field for a long time to come. But the book is much more than a description of investigations carried out using molecular-

beam methods and a compilation and discussion of the results obtained. By its clear definition of important lines of future development, it should stimulate research in this field, and by its meticulous attention to experimental detail, it should make easier the task of new research workers who may be attracted to such work. E. H. S. BURHOP

DIFFUSION AS A MATHEMATICAL PROBLEM

The Mathematics of Diffusion

By J. Crank. Pp. vi+347. (Oxford: Clarendon Press; London: Oxford University Press, 1956.) 50*s*. net.

THIS book has been written by a mathematician who has worked on diffusion for a number of years and has compiled many of the available solutions of the diffusion equation. It is a book on applied mathematics in which the problems are stated with the minimum of physical description, the main interest being in the method of solution and in tabulating generalized results. The style of presentation is to be recommended to all those who write for non-mathematicians. The discussion is always closely related to the physical problem in hand, particular examples as well as generalized solutions are given, and purely mathematical questions such as uniqueness of solutions, existence theorems and convergence, except where this concerns numerical calculations, are excluded.

The first six chapters, which treat the case of constant diffusion coefficient, form a counterpart to "Conduction of Heat in Solids", by Carslaw and Jaeger (Oxford, 1947). At first glance it would appear that this earlier book covers the subject adequately, it being necessary merely to replace thermal diffusivity by diffusion coefficient. However, many results have been given since 1947, the problems being dictated by the boundary conditions of particular experiments on diffusion rather than heat conduction.

In the present work there are two chapters on the related topics of diffusion with a moving boundary, and absorption with chemical reaction. The latter might well have been expanded; for example, nothing is said about absorption with second-order chemical reaction, a problem of physical importance which presents difficulties of a purely mathematical kind.

The remainder of the book deals mainly with variable diffusion coefficients and with numerical methods. These chapters are rather badly arranged, so that chapters on analytical and numerical solutions with variable diffusion coefficients are separated. There is a useful account of methods of finite differences, in which the brief mention of digital computing machines might have been expanded. A valuable chapter deals with the definition and measurement of diffusion coefficients. Here the author restricts himself to a mathematical discussion, the object being to use the analysis to extract the maximum of information from the experimental data. Such discussion is not out of place in this kind of book, but a little more experimental detail would be helpful, since the analysis available, and the type of experiment which is actually carried out, are interdependent.

The primary value of the book will be to research students beginning the study of diffusion. The earlier chapters will also be useful for advanced undergraduate teaching, while the established research worker will welcome the book as a comprehensive survey of the mathematical literature on diffusion during the past ten years.

It is interesting to note that the author is employed in an industrial laboratory. Until quite recently, theoretical books of this kind were always written by academic workers. Presumably industry is at last realizing the value of advanced mathematics, and it is to be hoped that more theoretical workers in industry will have time to write books of this quality. J. F. DAVIDSON

EARLY CIVILIZATION IN MESOPOTAMIA

From the Tablets of Sumer

Twenty-five Firsts in Man's Recorded History. By Dr. Samuel Noah Kramer. Pp. xxv+293 (40 plates). (Indian Hills, Colorado: Falcon's Wing Press, 1956.) 5 dollars.

FOR more than half a century the Sumerians have held an honoured place in history as the creators of urban civilization in the plains of southern Mesopotamia; but it is only during the past two decades that their highly developed poetical literature has become available in translation, and for this we are indebted first and foremost to the labours of Prof. Samuel Noah Kramer. Others had indeed paved the way by the elucidation of the grammar of the Sumerian language—a language unrelated to any known linguistic group—and by the publication of some of the tablets. However, these tablets, most of which were excavated as long ago as the 1890's, were found broken into many fragments, and at the conclusion of the excavations the fragments were divided between the Museum of the Ancient Orient at Istanbul, the University Museum at Philadelphia, and other collections, before any serious attempt had been made to effect joins. As a result, the fragments copied by scholars over a period of some thirty years were rarely large enough to yield intelligible sense.

The great achievement of Prof. Kramer has been due to his recognition that the most urgent need was the reconstruction of the texts of these compositions. With the support of several American learned societies and institutions, he has devoted all his energies to this task, travelling to Europe and Asia, copying unpublished fragments, and identifying those which belong together. The result has been the rediscovery of a lost literature, which deserves to be made known to a wider public than that reached by the learned journals where the first translations have usually appeared.

This is the main purpose which Prof. Kramer has set himself in this book. However, he has not, as in his earlier work, "Sumerian Mythology" (1944), confined himself to a straightforward presentation of the texts. Rather, he has used the texts to illustrate twenty-five different features of Sumerian civilization, each of which is represented as the earliest known occurrence of a phenomenon familiar in the modern world. These are his "Twenty-five Firsts in Man's Recorded History"—an expression with an oddly academic ring to British ears. Some of these

chapter-headings are merely descriptions of actual texts, such as "The First Love-song", "The First Proverbs and Sayings", "The First Tale of Resurrection", "The First Library Catalogue". Others are aspects of Sumerian society deduced from incidental references in one or more texts, such as "The First Bicameral Congress", "The First Experiment in Shade-Tree Gardening", "Man's First Cosmogony and Cosmology". The strange theocratic world-view of the Sumerians is well illustrated by the document translated under the heading "The First Historian". Another text reveals their quaint analysis of their own culture into more than one hundred elements (ranging from institutions like "kingship" to abstractions like "justice" and "terror"), which can be loaded into a boat and carried from one city to another. The remarkably human essay quoted under the title "The First Case of Apple-Polishing" gives a vivid impression of the life of a Sumerian schoolboy; and in the chapter entitled "Man's First Heroic Age", Prof. Kramer draws some far-reaching conclusions about Sumerian origins, which will doubtless not remain unchallenged.

This is a thoughtful and scholarly book, despite the colloquial tone sometimes adopted, particularly in the opening pages. The occasional glimpses of moments in the life of a Sumerologist and his search for 'joins' provide an attractive background to the description of the literature. O. R. Gurney

EVOLUTION OF MAN

The Fossil Evidence for Human Evolution

An Introduction to the Study of Paleoanthropology. By Prof. Sir W. E. Le Gros Clark. (The Scientist's Library—Biology and Medicine.) Pp. x+181. (Chicago: University of Chicago Press; London: Cambridge University Press, 1955.) 45*s*. net.

IF Pierre Charron in his "Treatise on Wisdom" was himself wise, the true science and study of man is man. Things, of course, were easier in the sixteenth century when fossil men were not in the laboratory or the study. How much happier we might be to-day if the wisdom of Charron had been coupled with the earlier wisdom of Job, who inquired: "What is Man, that thou shouldest magnify him ?".

Alas, in recent years the study of man has been attempted and magnified by all classes and conditions of men: geologists and palæontologists; anatomists and anthropologists; statisticians and geneticists; blood-group specialists and geochronologists; and adventurers and plain unvarnished liars. Many of the results have added to a confusion that Pope might well have had in mind when he wrote of the "Sole judge of truth, in endless error hurled".

There are, however, ways in which the judges can review the evidence and determine the end of error-making. It may be said that in this slim and elegant volume of a new and enterprising series in "Biology and Medicine", Sir Wilfrid Le Gros Clark has made a brilliant start. This is not easy to do. Man has the palæontological misfortune to be represented fairly generously in the Pleistocene and thus shares in the general regard for antiquity with the taxonomic confusion due to an almost super-abundance of contemporary specimens of the same animal. To all, ancient and modern, a generous amount of anthropomorphization is applied on the lines most familiar to the particular writer.

The answer to the question "What is Man ?" is thus both complex and unsatisfying. It is hard to separate the basic facts from a mass of observation and opinion and from an immense literature. Sir Wilfrid recommends the study of genetics, and rightly so. In "Genetics and the Races of Man" W. C. Boyd in 1950 forecast that more and more attention would become directed to blood-groups; and since he wrote, well over a thousand papers have been published on the subject—a sobering thought on the evolutionary picture. The strongest possible support must be given to Sir Wilfrid's plea that the student of human evolution should have a much closer acquaintance with the facts of functional anatomy. Without this and the assurance it gives for critical appreciation of structural analysis, all the highly important new work on the dating of the Pleistocene will be much reduced in value and the evolutionary pathways indubitably obscured.

The accumulation and recognition of a total morphological pattern is not simplified either when, through lack of anatomical knowledge, the desire to create new genera or species on every fragment of hominid bone persists. The current value of human remains is sometimes to be assessed by the value the observer places upon his observation rather than upon the intrinsic characters of the specimen.

It is of paramount importance that Sir Wilfrid here approaches the subject from the point of view of the scientific palæontologist and examines each piece of evidence as if it belonged to some animal other than man. He pays primary attention to the morphological and phylogenetic problems in taxonomy in relation to hominid evolution. This leads to a sound taxonomic system based on comparative anatomy, and placed on a background of geological time, that enables the distinction of hominid and pongid radiations to be made.

In the major portion of the book he follows the story of man's evolution in the logical way—from the known to the lesser known, the unknown and the postulated. In this route he recognizes taxonomic categories for *Homo sapiens*, *Homo neanderthalensis*, *Pithecanthropus* and *Australopithecus*.

Each of these sections ends with a diagnosis of the genus concerned and a discussion of its relationship with the other genera. The final chapter is on the origin of the Hominidae.

So far, the author says, no undoubted hominids have been found of an antiquity clearly older than the Early Pleistocene, and so far no fashioned implements have been proved of any greater antiquity. The relics of Pliocene hominids have yet to be discovered, though there is no doubt that such hominids existed.

It is thus all the more important to be able to be precise about the characters that these may have possessed and which will serve to distinguish them from the ten (at least) genera so far described of anthropoid apes of Pliocene and Miocene age.

The text is well illustrated by line-drawings, and there is a long and useful list of references. As a whole, the book will be of great interest to the anthropologist and quite invaluable to the student. Not the least of its appeal to vertebrate palæontologists is the fresh draught of common sense that the author lets in on the nomenclatural fog. This is a wise and valuable addition to the library of the palæontologist and physical anthropologist, and it can also be read by the layman.

W. E. Swinton

Arabic Astronomical and Astrological Sciences in Latin Translation

A Critical Bibliography. By Francis J. Carmody. Pp. vi+193. (Berkeley and Los Angeles: University of California Press; London: Cambridge University Press, 1956.) 21*s.* net.

THE purpose of this bibliography is to present in a co-ordinated form all known translations into Latin of Arabic works on astronomy. Most of the known Arabic works were translated into Latin during the medieval and renaissance periods by scholars who were specialists. In these translations they were able to exert a marked influence on European thought. The translations are of use to a far greater number of scholars than the Arabic originals would be; moreover, many of the original Arabic texts have not survived.

This bibliography has been prepared with great care by co-ordinating and corroborating the various editions and manuscripts. Several hundred manuscript texts have been examined at first hand. Works on astrology have been included as many of them contain technical information on such matters, for example, as planetary theories and improvements in astronomical constants. Mathematical works have also been included where they touch on the borderline of astronomy and deal with such matters as optics or the astrolabe.

A chronological arrangement of authors has been followed. Some brief notes about each author are given, followed by lists of editions and of manuscripts and some idea of the reliability of each. The contents of each work are described and an estimate of its significance is given. The locations of the several manuscript copies believed to be suitable for research are listed.

The preparation of this bibliography has evidently entailed an immense amount of research. It will provide an invaluable reference source for all students of Arabic astronomy. H. SPENCER JONES

Unione Internazionale di Chimica Pura e Applicata

Simposio Internazionale di Chimica Macromolecolare, Milano–Torino, 26 Settembre–2 Ottobre, 1954. (Supplemento a *La Ricerca Scientifica*, Anno 25.) Pp. xix+954. (Roma: Consiglio Nazionale delle Ricerche; New York: Interscience Publishers, Inc.; London: Interscience Publishers, Ltd., 1955.) 12,000 lire; 19.20 dollars.

THIS volume comprises some 106 papers contributed to the International Symposium on Macromolecular Chemistry, which was held under the auspices of the International Union of Pure and Applied Chemistry, in Milan and Turin, during September 1954.

The editors and printers have carried out their difficult and laborious task well, and the result is a substantial volume which gives an excellent permanent record, not only of the papers contributed, but also of the discussion remarks. The majority of papers are in English or French; but in all cases a lengthy résumé is given in Italian, French and German; so that the volume as a whole is a very valuable contribution to the international literature on this subject; it is clearly a necessity for the libraries of all institutions and laboratories concerned with macromolecular chemistry. It is only unfortunate, but quite understandable, that so much time should have elapsed between the conference and the volume. The subjects of the discussion were: (1) building reactions of macromolecules; (2) transformation reactions of macromolecules; (3) block polymers and graft polymers, preparation and properties; (4) cellulose and derivatives; (5) molecular weight determination and distribution; (6) branched polymers; (7) fibre-forming high polymers; (8) crystallization and transitions; (9) proteins; (10) general properties of polymers. J. A. V. BUTLER

Welt, Ich und Zeit

Nach unveröffentlichen Manuskripten Edmund Husserls. Von Gerd Brand. Pp. xviii+1012. (Den Haag: Martinus Nijhoff; London: B. T. Batsford, Ltd., 1955.) 9.50 florins.

THIS scholarly volume deals with the unpublished Husserl manuscripts. They represent the state of affairs existing at the end of the philosopher's life, and comprise his heroic attempts (never perhaps, in his estimation, wholly successful) to set phenomenology fairly and squarely upon an irreproachable methodological basis. Thus is explained the division of the work into two parts. In the first, no more than a general introduction to the subject is achieved, whereas in the second Husserl brings to bear his constitutive analysis with that particular brand of rigour which impelled him to regard phenomenology as a portion of a living science.

So, his meditations upon the return to experience occupy about one-third of the book, and his concept of temporality as fundamental for such experience the remaining two-thirds. The contrast is between occasional truths—with which we have to be satisfied in everyday life—and final validity. Observed historically, this means that the choice for Europe (as Husserl saw it) is between decay into barbarism or the rebirth of a spirit of philosophy in which objectivity would play a major part. It seems safe to deduce from these pages that something less violent than the "Enlightenment" of French savants is envisaged, but at the same time a system capable of eliminating the crudities of a merely pragmatic theory of knowledge. F. I. G. RAWLINS

The Theory of Differential Equations

By Dr. J. C. Burkill. (University Mathematical Texts.) Pp. ix+102. (Edinburgh and London: Oliver and Boyd, Ltd., 1956.) 8*s.* 6*d.* net.

INCE'S volume in the "University Mathematical Texts" gave an account of standard forms of explicit solution of ordinary differential equations. Dr. Burkill's companion volume takes this material as known, and proceeds to discuss conditions under which the existence of a solution may be proved, and those properties of the solution which may be deduced from the nature of the differential equation. The theory of the linear equation is concisely but thoroughly developed, an introduction to the Sturm–Liouville theory is given, solutions by means of infinite series and by contour integrals are carefully discussed. Chapters on the Legendre and Bessel functions serve as illustrations of general methods, and there is a brief introduction to asymptotic series. To cover this ground in a hundred small pages demands expository skill of no mean order, and it is a measure of the author's mastery to find a lucid account, easily intelligible to any good honours student, in so small a compass. Both as a text in itself, and as an introduction to more comprehensive treatises in this field, this book is a worthy member of the excellent series to which it belongs.

T. A. A. BROADBENT

ZOOLOGICAL RESEARCH AND ANIMAL LEARNING

ON the first day of the recent meeting of the British Association at Sheffield, the presidential address by Dr. W. H. Thorpe to Section D (Zoology) (see *Nature*, September 1, p. 473) was followed by a series of papers on "The Contribution of Zoological Research to Theories of Animal Learning".

Dr. Peggy E. Ellis (Hope Department of Entomology, Oxford) opened with an account of some experimental work on gregariousness in the desert locust (*Schistocerca gregaria*). Locusts reared in the laboratory in company with other individuals started to form groups some hours after hatching. When ten such individuals were tested under standard conditions in a ring-like cage, 70–80 per cent formed groups by the end of the first day, and the proportion remained more or less constant on the following days. Locusts reared in isolation and afterwards placed in crowded conditions, however, at first tried to escape from aggregations, and became gregarious only after several hours. When such individuals were tested in the ring-like cage, at first only 45–55 per cent formed groups, though the proportion rose to 70–80 per cent during the first day. Once the locusts had learned to aggregate, the behaviour seemed to be fixed. Thus insects kept under crowded conditions for three days, and then isolated for several days, did not lose their gregarious tendency.

From such experiments it seems that positive gregariousness depends on a learning process which resembles 'imprinting' in being rapid, irreversible and in involving a learning of 'supra-individual' characters. It differs from imprinting in that there is no sensitive period—individuals reared in isolation can learn to become gregarious at any age. Dr. Ellis related her experiments to the behaviour of hoppers in the field and her lecture was illustrated by a colour film taken in Ethiopia.

Dr. S. A. Barnett (Department of Zoology, Glasgow) then presented a paper on "Animal Motility and Learning". Early scientific work on animal movement was concerned primarily with the control of orientation and directed movement, the approach being narrowly mechanistic. Later, the importance and role of appetitive behaviour were appreciated, and investigators were concerned with the initiation as well as the orientation of the movement. Dr. Barnett used the term 'appetitive behaviour' only for behaviour which is (*a*) specifically motivated and (*b*) related to a consummatory act, and pointed out that some variable movement is not appetitive in this sense. Thus 'exploratory behaviour' is widespread among animals but does not lead to any specific act. Appetitive and exploratory behaviour are important in that they provide opportunity for learning—exploratory behaviour, in particular, makes possible topographical learning. Such learning is independent of the satisfaction of a particular need—a fact surprising to the learning theorist accustomed to manipulate motivation in experiments on learning, but not to the zoologist, who thinks in terms of survival value. In its independence of specific needs and acts, exploratory behaviour resembles play; such behaviour is of course of particular importance in the primates and in man.

The first paper in the afternoon, by Dr. R. A. Hinde (Ornithological Field Station, Department of Zoology, Cambridge) was concerned with "The Significance of Imprinting"—'imprinting' being used in its original sense to refer to the learning of the characteristics of their parents by young birds, and especially to the learning occurring when young nidifugous birds follow their parents. Among the characteristics of imprinting and the following-response discussed were:

(*a*) The diversity of objects which can elicit following. This can be understood functionally: responsiveness limited to one or a few stimulus patterns would be too selective, for the juveniles have not yet acquired a sense of constancy of size and shape and might fail to follow the parent when the latter was seen in varying postures and from varying angles.

(*b*) The ambivalence of the young, which tend to flee from their parents as well as to follow. This is a consequence of the selective advantage to adults of caring only for their own offspring and of driving off others.

(*c*) Irreversibility, rapidity and 'the sensitive period'. By virtue of such characteristics Lorenz believed imprinting to be a special form of learning. These characteristics are, however, by no means peculiar to imprinting, and can be found to a comparable degree in other contexts. Furthermore, all are covered by William James's laws of instincts.

(*d*) Imprinting and the parent-offspring relation. For a full understanding, imprinting must be considered in relation to all the behaviour patterns operating between parent and young: it plays an essential part in building up the parent-offspring relationship.

Since the characteristics of imprinting in birds can be understood functionally, learning with similar characteristics can be expected in other contexts with similar functional requirements. Thus the relationship between human mother and baby is built up in a similar way and shows many characteristics in common with the analogous relationship in birds, though the underlying mechanisms are presumably different.

A paper by Dr. I. M. L. Hunter (Department of Psychology, Edinburgh) entitled "'Trial and error' versus Insight" followed. Much of the problem-solving behaviour of animals seems to be 'almost human', and it seems reasonable to suppose that the animal 'understands' the situation. Such a supposition may, however, be wrong, for the animal has had a long learning history during which complex performances may have been developed by a process of trial-and-error learning which in no sense indicates the presence of thinking. In other cases the apparently intelligent behaviour of an animal may even turn out to be devoid of any learning at all: thus some of the strikingly purposeful behaviour of insects has been found to be instinctive, depending on a complex behaviour pattern which is, as it were, built into the organism.

The question whether animals think is thus more difficult to answer than it might appear. We need to know whether animals, whose past history is known in detail, can reorganize their past and present experiences to produce an anticipation of truly novel relationships within the problem situation. Only if this is so is it justifiable to speak of 'thinking' in animals. However, within the past ten years this

has been actually demonstrated. In chimpanzees, kept under continuous observation from birth, familiar material may suddenly and adroitly be used in a genuinely novel way as, for example, when a *T*-shaped stick is used to rake in food which lies out of manual reach beyond the bars of the cage. In white rats, certain types of maze experiment—the so-called reasoning and latent-learning experiments—have shown that these animals can make inferences about the spatial characteristics of certain situations, since they can run deftly from one place to another by paths which they have never before traversed. These and other findings lead to the conclusion that thinking exists not only in humans but also in animals, at least within the mammalian range.

Dr. Hunter suggested that the importance of such experiments not only demonstrates the existence of animal thinking but also contributes to the understanding of human thought processes. They have shown, for example, that thinking occurs only when the animal has had certain appropriate experiences in the past, experiences which contribute to thinking by furnishing, as it were, the raw material out of which a new response pattern can be formed. The experiences of early life seem to be especially important in this respect. Because it is easier to control the exact conditions under which animals can be reared (whether, for example, their visual environment is rich or lacking in detail), experiments with animals are particularly suited to yield information on the effect which early perceptual learning has on the emergence of thinking. In this way, animal experiments will supplement the considerable body of work which is currently being done on the nature and development of human thinking, and will provide answers to questions which could not be feasibly tackled at the human level.

Dr. A. J. Watson (Department of Experimental Psychology, Cambridge) discussed "'Stimulus-response' Theories of Animal Behaviour in the Light of Work on Instinctive Behaviour". He directed attention to three ways in which work on instinctive behaviour could lead to modification in theories of learning as devised by psychologists.

(*a*) Theories of learning are really theories of 'behaviour'—they attempt to predict what an animal will do in a certain range of circumstances. Furthermore, current learning theories are all in a sense stimulus-response theories; that is, given one set of stimulus conditions, and another of response conditions, an attempt is made to unite the two so that the second can be inferred from the first, but nothing is postulated about the actual mechanisms which intervene. Just because the initiating conditions, the final state and the intervening mechanisms are so complex, such attempts at prediction are almost bound to fail. Another type of approach is therefore necessary.

This is provided by instinct theories (for example, McDougall, Tinbergen) which permit distinctions between different 'kinds of responses' in different situations; for example, between appetitive and consummatory behaviour. Such distinctions cannot be accommodated within, for example, the Hullian framework, and permit an analysis of the problem so that it can be studied piecemeal.

(*b*) Instinct theories have emphasized the goal-seeking and directive properties of behaviour, which enter rather as an afterthought into theories of learning. This is related to the concepts of motivation used; in ethological theories the 'drive' selects the stimuli for which the animal searches in its appetitive behaviour, while in learning theory the drive serves only to provide a perpetual internal stimulus which may become linked to responses in the same way as an external cue. Further, the retroactive effect of drive reduction in learning theory is without parallel in instinct theories. The instinct-type theory, involving a 'goal-seeking' system, is superior to a stimulus-response system both because of its simplicity and because it can deal more readily with variable behaviour leading to a constant end. The retroactive effect of drive reduction is an unnecessary postulate, for goal-seeking machines can be made to learn what cues to search for without invoking any such principle.

(*c*) Dr. Watson suggested that instinct and learning theories differ in the nature of the goals which they postulate. While instinct theories have tended to emphasize the importance of acts as goals, psychologists have laid more stress on the perception of stimuli. The evidence is in favour of the latter view, and on this issue, therefore, ethologists seem to be farther from the truth than students of the theory of learning.

Thus ethological studies suggest that the student of the theory of learning should attempt to build a theory of a different logical type—with room for different 'kinds' of behaviour—and that he should modify his treatment of motivation. Ethologists, on the other hand, could usefully study the treatment of consummatory situations by learning theorists.

Finally, Mr. R. L. Reid (Department of Psychology, Aberdeen) spoke on "Avoiding Theory", expressing the view that the study of behaviour might progress more rapidly with fewer theories. Among the types of theory which could, in his view, profitably be discarded are:

(*a*) Escapist theories which attempt to explain a phenomenon away. Thus when a worm learns to turn into that arm of a *T*-maze in which it is shocked, its behaviour can be explained away by saying that 'worms like electroshock', or by supposing the synapses to be directly affected by shock. The first is mentalistic, the latter a physiological fairy tale, and both are unverifiable: they merely translate statements about behaviour into a different language.

(*b*) Behavioural cosmologies. These are superordinate theories which usually reflect the theorist's values and metaphysical assumptions, but are irrelevant to the practical aim of predicting behaviour. Arguments about holism and analysis or the purposeful nature of behaviour may obscure agreement about facts.

(*c*) Formal theorizing. This results from the use of hypothetico-deductive schemes (for example, Hull) and theoretical models (for example, Estes, Bush and Mosteller). These are unlikely to be fruitful in the study of broad areas of behaviour because of the complexity of the problems involved. Although they may be suitable for exploiting limited areas where the facts are already known, the urgent need—while the gaps in our knowledge are still so great—is for factual survey work. Such formal approaches are inevitably constrictive: although there is room for formal theorizing, the less pretentious inductive approach must not be neglected.

(*d*) Physiologizing. In thinking about complex behaviour it is sometimes disadvantageous even to consider possible mechanisms. Thus the concepts of 'set' and 'attention' were disposed of in the early stages of behaviourism largely because they did not

fit in with the picture of the nervous system then held. They have now been restored on the grounds that they are physiologically respectable. Behaviour is as real and as regular as the physiological events underlying it, and reduction from the one realm of discourse to the other is unnecessary.

Mr. Reid concluded by hoping that zoological research will continue to provide empirical studies of learning in a wide variety of animals, and to examine the effects of hitherto neglected variables, rather than indulge in speculative theorizing.

In his concluding remarks, Dr. Thorpe directed the attention of those present to the growth of liaison between psychologists and zoologists studying behaviour. Five years previously they would barely have understood each other's problems, whereas now each has a broad knowledge of the other's work and they are aiming at similar goals. R. A. Hinde

THE PHYSICAL PROPERTIES OF METALS

ALTHOUGH the British Association has no section dealing specifically with metallurgy, it was to be expected that the recent meeting in Sheffield should give prominence to the subject. Thus the morning session of Section A (Physics) on September 3 was devoted to physical metallurgy, and Sir George Thomson, president of the Section, presided. The first paper, "The Physical Approach to Metallurgy", was presented by Prof. A. G. Quarrell (Sheffield) and served as an introductory lecture to the morning's proceedings. It emphasized the complexity of the technology of metals to-day and described how physics has provided not only the techniques for studying metals but also the necessary mental approach to the ultimate nature of metals which is leading to an understanding of their strength and behaviour.

Metallurgy as a science dates from the application of the microscope by Sorby to metal specimens at Sheffield in 1863, and a unique series of ferrous metallographic specimens laboriously prepared by Sorby in 1864 was on view at the meeting. Fortunately, these have been preserved by a cover-glass cemented on each prepared surface, and many may still be examined at high magnification. Sorby realized that the structure visible in polished and etched specimens is characteristic of the metal and the way it has been produced, and some time later it was shown that the appearance is also related to the mechanical properties of the metal.

The maximum magnification with the optical microscope is about × 2,000, but about fifteen years ago the development of the electron microscope led to an increase in the useful magnification up to × 100,000. Unfortunately, direct observation of the metal surface is normally impracticable, and a replica which is transparent to electrons must be examined. The initial unreliability of replica techniques prevented the general acceptance by metallurgists of electron microscopy, but the use of vacuum-deposited carbon replicas during the past two years has completely revolutionized the situation, and the electron microscope is now a most powerful metallurgical tool.

The early optical microscopic examination of metals was soon supplemented by thermal and dilatometric studies, enabling the composition limits of the various metallic phase fields to be determined and constitution diagrams to be constructed. The understanding of the alloy formation, however, had to wait for the technique of X-ray diffraction and for the concept of a metal as an assembly of charged ions surrounded a cloud of the conducting electrons. Hume-Rothery then showed in 1926 that the limiting solubility in monovalent metals such as copper and gold depends on the relative atomic diameters of the metals concerned, and that the structure of the intermediate alloy phases depends on the ratio of valency electrons to atoms in the alloy. These rules unfortunately fail to explain the alloying behaviour of the more complex alloys which are important in modern technology, and the approach to these alloys is still largely empirical.

The appreciation of the crystalline structure of metals has also made possible the study of the factors influencing the strength of metals. However, the theoretical strength of metals calculated from their atomic properties is 100–1,000 times greater than the measured stress required to produce permanent plastic deformation. This weakness is due to imperfections in the lattice, known as dislocations, and since the 'edge' dislocation was introduced in 1934 a complex theory of dislocations and their behaviour in crystal lattices has been developed. It has been calculated that the stress necessary to move a dislocation, if the interactions between the dislocation and the stress fields due to alloying atoms and precipitates are taken into account, is similar to the stress required to initiate slip in practice.

The dislocation theory of plasticity has been developed by theoretical physicists such as Mott and physical metallurgists such as Cottrell, and while strain-hardening, yield-points and crystal growth have been explained satisfactorily, only a beginning has been made towards the understanding of creep, fatigue and brittle fracture.

Creep is an example of a phenomenon of interest to both physicist and metallurgist; it was studied by Andrade in 1910 as a purely scientific phenomenon, but in 1920 Dickinson, in Sheffield, appreciated the importance of creep in steels at high temperatures and carried out the first long-time creep tests. These showed that at high temperatures much lower stresses would cause stretching and failure in the long-time creep test than in the short-time tensile test. The importance of creep in modern engineering has grown enormously in recent years with the trends towards high operating temperatures and pressures, and a large proportion of our metallurgical man-power is concerned with the development of new creep-resistant alloys which, for example, would be expected to last for many years at 570° C. in a modern power station.

Although complex metallurgical problems such as the mechanism of creep and its relationship to structure have not been solved completely by the physical approach, and resort must be made to semi-empirical methods, the major contribution of physics to metallurgy has been to give metallurgists a new mental attitude. Metallurgists are no longer satisfied with *ad hoc* solutions of immediate problems and have become increasingly anxious to provide fundamental explanations of important phenomena.

This truly scientific approach will undoubtedly result in rapid advance of the science of metallurgy.

"The Microstructure of Metals and Alloys" was the subject of a paper by Prof. C. S. Smith (Chicago). At the time of Sorby, the grains visible in metallographic micro-sections were not recognized as single crystals, because the single crystals of minerals in Nature were always expected to be regular polyhedra. However, it is now realized that the requirements of space filling prevent metal crystals in a polycrystalline aggregate from exhibiting regular crystallographic faces, and the geometry of the grains is governed by the condition that the interfaces contribute minimum energy to the system.

The interfaces themselves are of considerable interest as the interface atoms belong to both adjacent crystals. They have abnormal co-ordination with their neighbours, and abnormal spacing from them, making the interface a high-energy region which may be regarded as constituting a thin layer of liquid between the grains. A micro-section is essentially a random two-dimensional section through an aggregate of grains, and in a section the relationship between the number of polygons (P), the number of edges (E) and the number of corners (C) is given by the two-dimensional form of Euler's Law :

$$P-E+C=1$$

This shows that a grain can have any number of sides greater than two, but that hexagonal polygons are the most common.

Although polygons of other than six sides are possible and do occur, the condition of minimum energy in the boundaries invariably results in the grain boundaries meeting in threes at angles of 120°, and such junctions can only be accommodated by curved boundaries. In three dimensions the grain edges meet each other in fours at angles of 109½° to each other at each junction. These four crystal junctions are the only constant unit of structure and may be connected in innumerable ways. A three-dimensional array is thus made up of irregular grains each with approximately fourteen faces, and each face having an average of 5⅐ faces.

The arrangement of the grains in beta brass can be revealed by fracturing in the hot-short range and is analogous to that of the bubbles in a soap froth or the cells in human fat, as they are all controlled by the requirement that the interface energy, and hence the area, must tend to a minimum.

Such grains show curved faces, and if a metal is heated to the temperature at which diffusion can occur, the boundaries move towards their centres of curvature and the smaller, convex, cells disappear while their concave neighbours grow. The final minimum-energy state would consist of a single crystal.

In two-phase alloys the same relations between the grains apply, but the dihedral angle between the grains usually differs from 120° as the interfacial tensions are usually different. This angle is often zero for a liquid between two crystals which breaks all coherence, as in brass in contact with mercury or molten solder. In solid two-phase alloys the angle is often between 90° and 100°, showing that the chemically different interface is of lower energy than that between the two crystals of the same phase.

In this treatment it has been assumed that the energy of the interface is independent of the orientation between the grains forming the grain boundary ; but this generally correct assumption breaks down at certain critical orientations. Thus the twins and plate-like precipitates which are due to a nucleation and growth processes, orientate themselves to give the lowest possible energy, and this outweighs the spatial improbability of such relationships. The majority of precipitates within the grains of heat-treated structures are of this type, exhibiting an orientated, polyhedral habit.

These general principles of space filling by polyhedra to give the minimum area, and hence minimum energy, of the interface, apply not only to metals but also to other microcrystalline materials such as ceramics and rocks, and all structures and transformations can be classified in terms of the structure of the boundary and the kind of adjustments in composition and position which occur as the boundary moves.

Dr. N. J. Petch (Leeds) spoke next on "Brittle Fracture", a subject he has made peculiarly his own. A fracture is defined as brittle if it is associated purely with elastic deformation and the fractured metal thus shows no evidence of deformation.

The difference between a brittle and a ductile crack is in its method of propagation. In the former case the applied stress required to spread the crack decreases as the crack grows ; hence the maximum stress is required initially and catastrophic propagation occurs once the crack is initiated. If the crack is ductile, some energy is expanded in deforming the ends of the crack, and continued straining is necessary to spread the crack.

Although a mild steel may be quite ductile in a tensile test, it may behave in a brittle manner when incorporated into a structure. This difference has become more obvious with the use of all-welded structures, in which a crack, once started, can often travel a very large distance before being arrested by a physical discontinuity. More than one-fifth of the 5,000 ships built under the American emergency shipbuilding programme during the Second World War suffered serious cracking within three years, and eleven had broken completely in half by 1951. Other serious fractures have occurred in bridges and oil-storage tanks, and outstanding fractures a mile long have been reported in 30-in. diameter natural gas pipe-lines in the United States. These fractures travel with speeds approaching the speed of sound in the metal and a mile-long fracture would thus occur in about one second.

It is found that brittle materials exhibit a strength which is approximately one-thousandth of that calculated for a perfect solid, and Griffith laid the foundation of our present understanding of brittle fracture by showing that in glass and silica this weakness is due to minute cracks acting as stress concentrators. The current ideas of metallic fracture regard these stress concentrators as dislocation pile-ups on slip planes blocked by grain boundaries, and the stress concentration of × 1,000 necessary to account for the difference between the observed and theoretical strengths would require a thousand piled-up dislocations, which is not unreasonable. The difference between brittle and ductile materials is in the behaviour at the pile-up ; in ductile metals crack formation is accompanied by plastic deformation, so that energy is lost in initiating the new dislocation movements, and the resulting crack is too small to propagate itself ; many small cracks are thus formed which eventually join up and cause failure. In brittle failure, the propagation is elastic and no plastic deformation occurs, so that all the

energy of the dislocation pile-up goes into the production of the crack and the initial crack is sufficiently long for spontaneous propagation.

Metals are most prone to brittle failure if movement of the dislocations, that is, plastic deformation, is difficult; for example, mild steel shows more brittleness than, say, copper because the dislocations become locked by carbon atoms, and this effect becomes more pronounced the lower the temperature.

The dislocation model also explains why brittle cracking is often observed in structures when a test piece of the same steel is ductile. Notches in the structure cause stress concentrations at their roots at which the rate of strain is high and dislocation movements are not rapid enough to avoid brittle fracture.

In general, the physical explanation of brittle fracture in polycrystalline metals is satisfactory, but the mechanism of the fracture in single crystals is still obscure.

In his paper on "The Metallurgy of Nuclear Energy", Mr. L. Rotherham (United Kingdom Atomic Energy Authority) outlined the metallurgical problems in the design of nuclear reactors. A thermal reactor consists essentially of a lattice of uranium rods surrounded by a moderator, usually of graphite. When a chain reaction is allowed to take place in the uranium, heat is generated and the pile must be continuously cooled. This is accomplished in the Harwell and Windscale piles by the use of air as a coolant and at the Calder Hall power station by carbon dioxide under pressure.

The problems encountered may be divided into those of a conventional nature which might be encountered in general chemical engineering, and those in which radiation effects are important. A typical conventional problem was the construction of the steel pressure vessels at Calder Hall, which are 40 ft. in diameter and 60 ft. long, containing carbon dioxide under pressure to increase its efficiency as a coolant. These vessels were fabricated by welding two-inch thick steel, and to avoid the brittle fracture dangers discussed by Dr. Petch, they were made of special steels.

The fuel elements consist of uranium rods protected by aluminium or magnesium 'cans' to prevent attack by the coolant. Unfortunately, uranium has low crystal symmetry with three markedly differing coefficients of thermal expansion along the three orthogonal crystal axes, and on heating and cooling considerable thermal distortion can occur in polycrystalline material. The effect of irradiation is similar, and considerable dimensional changes can also occur due to the internal strains produced by the fission products, which occupy more space than the parent uranium atoms. This effect is aggravated if atoms of rare gas are produced, which afterwards diffuse into voids and set up a considerable pressure. At 200° C. a single crystal of uranium would approximately double its length after the fission of one in a thousand uranium atoms. Irradiation of cast polycrystalline material produces an orange-peel surface wrinkling, while rolled material may increase its length and decrease its width, or vice versa, according to the rolling temperature. A further complication arises from the phase change in uranium at 650° C., as repeated heating and cooling through this transformation leads to severe distortion and surface roughening. The metallurgists' problem is to minimize these effects by heat-treatment to produce smaller grain-size, to avoid any preferred orientation due to fabrication and to study the effects of alloying which might stiffen the rods and thus help to resist the effects of internal pressure.

It is also possible to prevent distortion of the fuel elements by enclosing them in a rigid can. The Harwell and Windscale reactors employ aluminium cans; but as the fuel elements are discharged for plutonium extraction after relatively short periods in the pile, the distortion problems are not severe. In the Calder Hall reactors, power and not plutonium production is the main objective, and to withstand the severe distortion and growth consequent on a high burn-up of uranium, magnesium was chosen for the canning material. Magnesium has a higher creep strength than aluminium, and as it has a lower neutron absorption cross-section, a thicker and more rigid sheet can be used for the can.

In the future, the higher temperatures of fast reactors as envisaged at Dounreay will preclude the use of aluminium and magnesium as canning materials, and new metals will have to be employed. The choice is limited by the requirement that the metal must have a low neutron absorption, and use must be made of the rarer metals beryllium, zirconium, niobium, vanadium, tungsten and molybdenum. Of these metals niobium perhaps offers the most advantages, in that it is the most resistant to attack by uranium and liquid sodium, it has good high-temperature strength and it is extremely ductile and therefore readily fabricated into cans.

Up to the present, the extraction and properties of the rarer metals have been explored, and future developments will lie in the direction of enhancing the usefulness of these metals by alloying.

R. G. Ward

THE ELECTRICAL CONDUCTIVITY OF THE HEAD-WATERS OF THE WHITE NILE

By R. S. A. BEAUCHAMP

East African Fisheries Research Organization, Jinja, Uganda

FOR many years records have been kept of the levels of the lakes that form the head waters of the White Nile, and estimates have been made of the amount of water discharged from these lakes. Yet some uncertainty still exists regarding the relative contributions made by these various sources. This is not surprising when one considers the extent and complexity of this lake and river system, and the fact that the whole area is subject to high and irregular rates of evaporation and precipitation. The purpose of this article is to indicate the value of keeping, in addition to records of lake-levels and rates of discharge, records of the electrical conductivity of the water at particular points in the system. The electrical conductivities of these lakes and rivers cover a wide range of values. A study of

these values provides information on the amounts of water derived from different sources.

Lakes Victoria and Kyoga form a major portion of the head waters of the White Nile; the outlets of these two lakes give rise to the Victoria Nile, which discharges into the northern end of Lake Albert close to its outlet. The rest of this system is composed of a series of three lakes: Lakes George, Edward and Albert. Values for the electrical conductivity of the water contained in these five lakes remain nearly constant and are as follows:

Lake Victoria	100	Lake George	160
Lake Kyoga	330	Lake Edward	910
	Lake Albert	720	

The more important rivers in this system are the Victoria Nile, already referred to, the Semliki and the Albert Nile. The Semliki flows from Lake Edward to Lake Albert. The Albert Nile is the outflow from Lake Albert.

The electrical conductivity of the Victoria Nile, measured just below the Murchison Falls at Fajao, remains at a nearly constant value of 110 units.

The electrical conductivity of the Semliki varies along its course and at different times of year. The Uganda Hydrological Survey Department has on this river three recording stations. The first of these stations is at Ishango, close to the outlet from Lake Edward; the second is at Ngamba, about half-way down the river; and the third is at Bweramule, thirty miles from Lake Albert. My thanks are due to the Hydrological Survey Department for supplying samples of water from these three stations.

At Ishango the electrical conductivity of the water is almost constant at 910 units, being undiluted Lake Edward water. At Ngamba values recorded range between 780 and 885 units; at Bweramule they range between 360 and 800 units (see Fig. 1). The variations in conductivity of the water at Ngamba and at Bweramule indicate that the Semliki at times receives considerable quantities of water of low conductivity on its way to Lake Albert.

The conductivity of the Albert Nile measured at Pakwach ranges between values of 160 and 355 (see Table 1). My thanks are due to the Commander-in-Charge, Lake Albert, East African Railways and Harbours, Butiaba, for samples of water from Pakwach and from mid-lake. It can be seen that conductivity values at Pakwach are entirely different from the value of 720 recorded for Lake Albert. The Albert Nile cannot therefore be considered simply as the outlet of Lake Albert.

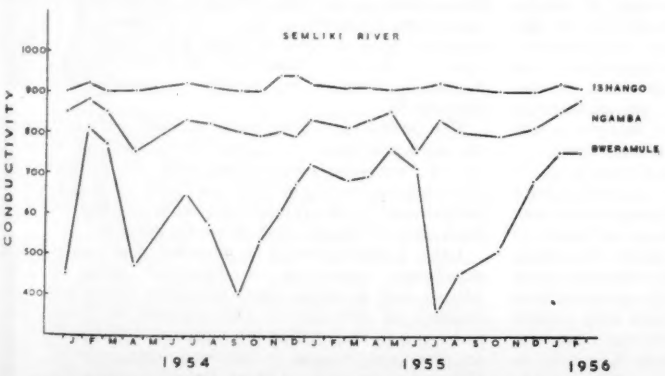

Fig. 1. Values for the electrical conductivity of the Semliki River at three stations

Table 1. Values for the Electrical Conductivity of the Albert Nile and Estimates of the Percentage of Lake Albert Water contained in this River

Date	Electrical Conductivity Pakwach	Per cent Lake Albert water at Pakwach	Date	Electrical Conductivity Pakwach	Per cent Lake Albert water at Pakwach
25.3.54	310	33	26.8.54	210	16
1.4.54	320	34	2.9.54	190	13
8.4.54	260	24	9.9.54	240	21
15.4.54	300	31	20.9.54	160	8
23.4.54	260	24	7.10.54	185	12
29.4.54	300	31	14.10.54	185	12
2.5.54	300	31	30.10.54	190	13
6.5.54	320	34	25.11.54	355	40
13.5.54	260	24	12.12.54	250	23
27.5.54	295	30	16.12.54	300	31
3.6.54	220	18	23.12.54	250	23
10.6.54	275	27	30.12.54	320	34
13.6.54	200	14	4.1.55	300	31
17.6.54	230	19	6.1.55	300	31
1.7.54	230	19	9.1.55	300	31
8.7.54	290	29	20.1.55	280	28
11.7.54	270	26	23.1.55	290	29
15.7.54	230	19	27.1.55	300	31
22.7.54	270	26	6.2.55	250	23
29.7.54	285	29	10.2.55	340	37
12.8.54	280	28	20.2.55	250	23
19.8.54	205	15	3.3.55	280	28

Samples of water collected along a course running south from Fajao out into Lake Albert show that very little water from the Victoria Nile finds its way into Lake Albert. At a point approximately ten miles south of the Victoria Nile Delta, the water has a conductivity value of 720. It seems, therefore, that nearly all the water in the Victoria Nile travels almost directly into the Albert Nile.

Summarizing the information given above and the data contained in Fig. 1 and in Table 1, it can be said that the waters of the five lakes, which form the head waters of the White Nile, have electrical conductivities which remain constant at values characteristic for each lake, and that the water in the Victoria Nile also has a characteristic and almost constant electrical conductivity. On the other hand, the water in the lower reaches of the Semliki and in the Albert Nile show widely fluctuating values.

The electrical conductivity of natural waters is directly related to the concentration of dissolved electrolytes contained in them, and in normal circumstances a mixture of two samples of water will have a conductivity determined by that of the two samples and the relative amount of each contained in the mixture. Thus, if the conductivity of two confluent waters and that of the resulting mixture are known, it is a simple matter to calculate the relative amounts of water supplied by the two streams.

Calculated values for the percentage of Lake Albert water contained in samples of water from Pakwach on the Albert Nile are given in Table 1. These values indicate that at times the amount of Lake Albert water in the Albert Nile may be as high as 40 per cent and at other times as low as 8 per cent. For the purpose of these calculations the conductivity of the water at Fajao was taken to be 110 units and that of Lake Albert water 720 units. In order to test the validity of the calculations for the percentage content of Lake Albert and Victoria Nile water in the Albert Nile, appropriate mix-

tures of these two waters were made and the conductivity of these mixtures measured. In all cases the calculated values agreed with the actual values.

For many years estimates[1] have been made of the discharge of water at Fajao and of the amount of water flowing down the Albert Nile. These estimates indicate that the amount of water flowing down the Albert Nile is on the average about 10 per cent more than the flow at Fajao. Although the discharge at Fajao can be measured reasonably accurately, it is, unfortunately, impossible to measure the flow down the Albert Nile with the same degree of accuracy, because the banks of this river are deeply overgrown with papyrus. Considerable quantities of water no doubt flow through this fringing belt of swamp vegetation, but it must be nearly impossible to determine how much. In the circumstances, it would seem to be advisable to consider with some reserve the recorded rates of discharge down the Albert Nile.

The question of how much water in the Albert Nile is derived from the Victoria Nile and how much from Lake Albert has not previously received close attention. The Victoria Nile has usually been considered as a tributary flowing into Lake Albert, without regard to the fact that it enters the Lake so close to the outlet that, as shown above, most of its water passes straight into the Albert Nile. Whether the waters of the Victoria Nile flow directly into the Albert Nile or not may at first appear to be a point of academic interest. However, as it is difficult to estimate accurately the flow in the Albert Nile, any information that may help towards obtaining a more accurate estimate is worth considering.

Although it is not possible to say that all the Victoria Nile water flows directly into the Albert Nile it seems, from the evidence available, that more than 90 per cent of the discharge at Fajao does so. It thus appears that by using the known discharge at Fajao and the conductivity values recorded at Pakwach, an approximate estimate of the amount of water flowing down the Albert Nile could be obtained. This estimate may be at least as, if not more, accurate than the direct measurements made at Pakwach. At a later date it is hoped with the co-operation of the Uganda Hydrological Survey Department and the Egyptian Ministry of Public Works to go into this matter in greater detail.

Apart from the above considerations, records of the conductivity of the water at Pakwach could be of value for other reasons. It can be seen that over quite short periods of time values for conductivity may vary considerably; these fluctuations could be used to estimate the time taken for water to travel downstream, probably at least as far as Bor in the Sudan. J. F. Talling, of the University of Khartoum (*in litt.*), has noted that marked fluctuations occur in the conductivity and chemical composition of the water in the neighbourhood of Bor; he tentatively explained these fluctuations as due to changes in the contribution of water derived from Lake Albert.

In a memorandum[2] addressed to a Commission to consider the question of the salinity of Lake Albert and its bearing on irrigation, H. E. Hurst stated that the proposed regulation of Lake Albert by means of a barrage at Mutir, some miles below Pakwach, would not increase the salinity of the summer water supply to Egypt by an amount which could damage either the cultivation or the land. This may indeed be so, but Hurst assumes that under the new conditions all the water from the Victoria Nile will, as at present, find its way into the Albert Nile. However, the possibility exists that raising the level of Lake Albert may have a very significant effect on the fate of Victoria Nile water. At present this water travels through more than a right angle in order to reach the outlet of the Lake; it seems that the flow of Lake Albert water across the mouth of the Victoria Nile delta brings this about. This deflexion of the Victoria Nile water is no doubt further assisted by the way the delta has been formed.

If the level of Lake Albert is raised, the effect of existing channels in the delta will be largely abolished and the velocity of the outflow from Lake Albert will be reduced. At present the depth of water across the outlet is slight. At one point in the channel used by the lake steamer the maximum depth is only three metres. Raising the Lake by only two metres would reduce the velocity of the outflowing current very considerably; this current might then not be sufficient to deflect the Victoria Nile waters towards the outlet. The consequence of this would be to allow more Victoria Nile water to flow into Lake Albert. Thus, the outlet from Lake Albert might in the future come to consist mainly of typical Lake Albert water. The introduction of large amounts of Victoria Nile water into Lake Albert and the withdrawal of typical Lake Albert water might have a very profound effect on the biology of the Lake by causing a reduction in its salt content and perhaps bringing about a reduction in fertility. It is also possible that the new conditions might favour the development of thermal stratification and thus cause great changes in its biological economy. These ideas are at the moment rather speculative, but it is held that more hydrological data should be collected before proceeding with plans to build a barrage at Mutir.

In the memorandum quoted above, Hurst states that the Semliki River has a salt concentration the same as that of Lake Albert. The data contained in Fig. 1 show that the salt concentration varies very considerably and is only the same as that of Lake Albert occasionally. These fluctuations in the salt content of the waters of the Semliki merit further consideration. They are undoubtedly brought about by varying amounts of water received from streams running off Mt. Ruwenzori. Unfortunately, there are not adequate data available on the electrical conductivity of these streams to permit an accurate estimate to be made of the amount of water received from these sources. Some samples of water have been obtained from these rivers; they contain a low concentration of dissolved salts and their electrical conductivity is about 40 units. However, as only a few streams have been sampled, no reliable average value can be given; but if it is assumed that an average value of about 40 units is probable, it appears that at times more than half the water entering Lake Albert by way of the Semliki is derived from Mt. Ruwenzori.

The Semliki is a large river and certainly influences the flora and fauna of Lake Albert, both on account of its chemical composition and its temperature. The chemical and physical condition of this water is determined by the relative amounts of water received from Lake Edward and from Ruwenzori.

Lake Edward should be considered as contributing significant quantities of dissolved salts to Lake Albert, and at times plant nutrients which affect the fertility of this lake. The amount of these plant nutrients in the outflowing water at Ishango depends on the hydrological conditions obtaining in Lake Edward at the time. Lake Edward becomes thermally

stratified for considerable periods; at such times plant nutrients in the surface waters are reduced to very low values. However, when thermal stratification is broken down and water from the deeper layers is brought to the surface, high concentrations of nutrient salts are found in this water. It has been shown[3] that in the waters of East Africa sulphates are frequently in short supply; they may therefore be used as a suitable and convenient chemical label or indicator of the potential fertility of the water. At those times when Lake Edward is thermally stratified, sulphates are reduced to one or two parts per million; but after 'turn over', values as high as one hundred and twenty parts per million have been recorded.

It is probable that significant amounts of certain plant nutrients, such as phosphates, are supplied to Lake Albert by the water derived from the Ruwenzoris, but there are few adequate observations on this.

There is little doubt that the water from the Ruwenzori streams is colder than the water from Lake Edward, and that at those times when the Semliki contains a high proportion of water from Ruwenzori, it will be at a lower temperature than when more of the water is derived from Lake Edward. Further observations need to be made, but it seems that the influx of this cooler water into Lake Albert may explain the periodic mortalities of Nile perch in this Lake. This water may be expected to flow into Lake Albert beneath the surface and, while flowing along the bottom of the Lake in contact with the warmer bottom deposits, may become deoxygenated. Fish swimming into this water are likely to be asphyxiated. This hypothesis is discussed in a paper by Fish[4] on the oxygen requirements of certain fish.

It is submitted that further hydrological data collected on the head-waters of the White Nile should include records of the electrical conductivity of the waters of the Semliki and the Albert Nile, as these observations are likely to add considerably to our understanding of the biology of Lake Albert and may also be of great importance with regard to projects aimed at making greater use of these waters for irrigation in the Sudan and Egypt.

[1] Hurst, H. E., "The Nile Basin". First Supplement to vol. 2, 727
[2] Hurst, H. E., "The Effect of the Salinity of Lake Albert on Future Irrigation in Egypt". Unpublished report (1950).
[3] Beauchamp, R. S. A., *Nature*, **171**, 769 (1953).
[4] Fish, G. R., *J. Exp. Biol.*, **33**, 186 (1956).

OBITUARIES

Mr. L. Bainbridge-Bell

LABOUCHÈRE BAINBRIDGE-BELL, who died on August 7, interrupted his education at Emanuel College, Cambridge, in 1914 to join the Signals Branch of the Royal Engineers and won the Military Cross in the battle of the Somme. Later he served in Egypt as a wireless officer in the R.F.C. and R.A.F. After demobilization, he spent six years with the Radio Communication Co., and in 1927 joined the Radio Research Station, Slough. In 1935 he became one of the group of scientists working, under the direction of R. A. (now Sir Robert) Watson-Watt, on what is now known as radar. For his part in this development he received an award of £2,400 from the Royal Commission on Awards to Inventors, and it was characteristic of Bainbridge-Bell that he immediately gave the money to charity.

In the first week of the Second World War he was seconded to H.M. Signal School at Portsmouth and shortly afterwards flew to Montevideo, when the German battleship *Graf Spee* was scuttled in the River Plate; after many adventures, he was able to confirm that the enemy was using shipborne radar, and he returned to Britain with invaluable details of the equipment.

After the War, Bainbridge-Bell re-organized the arrangements at the Admiralty Signals Research Establishment for producing technical reports, establishing a system of centralized editing which not only relieved harassed laboratory workers of much paper work but also ensured uniformity of layout, presentation and illustration. He represented the Admiralty on the Glossaries and Symbols Panel of the Armed Services and was also a member of the British Standards Institution committees dealing with graphical symbols and with the glossary of terms used in telecommunications. It was mostly due to his efforts that the Services standard of graphical symbols and the British Standard were each modified so that they became identical, with the logical next step that the Services could cease a separate publication and use the British Standard. Bainbridge-Bell retired from the Royal Naval Scientific Service in August 1953, on reaching the age of sixty, joined the British Standards Institution and became secretary of the committees on which he had served as a member for many years.

Bainbridge-Bell was one of the few men who have combined science with classical scholarship and hence was most valuable on a committee dealing with the definitions of technical terms. At times, his ruthless exposure of false or incomplete reasoning, of lack of precision, or of attempted concealment of ignorance by verbosity, could be embarrassing. Yet he was essentially kind and had the respect and regard of numerous friends for his tremendous energy and enthusiasm.

J. READING

Mr. J. W. Lester

JOHN WITHERS LESTER, whose death at the untimely age of forty-seven occurred on August 9, was born in Walsall, Staffs, in 1908 and was educated at Wrekin College where, besides taking a prominent part in Rugby football and boxing, he devoted much of his spare time to natural history, either in the field or in reading books on the subject. In fact, from a very early age he displayed an interest in animals, particularly reptiles and amphibians, and even when only five had acquired a sure skill in catching them. This strong interest his parents wisely encouraged, and when during his later school-days the family moved to Cornwall, Jack, as he was known to all, continued his field excursions, becoming in particular very skilled in the hunting of badgers. His early career was with the Bank of British West Africa, and during his six years in Sierra Leone he devoted much of his spare time and energy to collecting animals of all kinds. He sent home many interesting specimens to several zoos, especially

that at Primley, Devon, owned by the late Herbert Whitley, and when he resigned from the Bank on his marriage in 1936, he became actively associated with the Primley Zoo, being responsible for the building up of the reptile and tropical house there.

During the Second World War, Lester was an officer in the R.A.F., and then in 1946 he was appointed curator of reptiles at the London Zoological Gardens, where it soon became evident that he was the right man for the job. During the next few years he made several trips to West and East Africa on behalf of the Zoological Society, collecting and bringing back many specimens of mammals, birds and insects, as well as reptiles and amphibians, of interest and rarity. In 1954 he led an expedition to Sierra Leone in conjunction with the B.B.C. Television Service, the outcome of which was the greatly appreciated television series "Zoo Quest", and last year he led a second such expedition to British Guiana.

In January last he was awarded the Zoological Society's Silver Medal. He was a founder-member of the British Herpetological Society.

Throughout his years at the Reptile House of the London Zoo, Lester was unstinting of the time he gave to advising visitors on the care of reptiles, as well as to giving evening lectures to schools and many small societies, and he was always keen to encourage the growth of natural history interests in the young. He made many broadcasts and television appearances. A man of charming, yet unassuming personality, always so willing to share his love of natural history and to help others to that end, his death is a sad loss to his many friends, both at home and overseas as well as to the Zoological Society.

L. C. Bushby

NEWS and VIEWS

Astronomical Society of South Africa: Gill Medal

The Astronomical Society of South Africa announces the first award of the newly established Gill Medal to Dr. Harold Knox-Shaw, "For outstanding services to Astronomy and in particular to South African Astronomy in the successful establishment of the 74-inch Radcliffe Reflector at Pretoria". The Gill Medal commemorates the work of Sir David Gill, one of the most distinguished scientists to work in Southern Africa. Gill was H.M. Astronomer at the Cape during 1879–1907, and is celebrated for his numerous contributions to astronomy, notably

his determination of the solar parallax, his leading part in the introduction of photography into astronomy, and his design of the Cape Transit Circle, a model for many later instruments. The Medal, which is in silver, of a diameter of two inches, bears on the obverse a portrait of Gill in low relief, and on the reverse, a representation of Gill's favourite instrument, the 7-in. heliometer. On the same face is the inscription—"Awarded for services to astronomy". The Gill Medal is probably unique among honorary awards by scientific societies in that it was designed by a president of the Society during his year of office, for Dr. Peter Kirchhoff of Johannesburg, the well-known sculptor, is also a keen amateur astronomer, and executed the design during his presidential year. The medal is to be awarded not more than once in any year for services to astronomy, preference being given to services to astronomy in Southern Africa.

Dr. H. Knox-Shaw

Dr. Knox-Shaw was educated at Wellington and Trinity College, Cambridge. He began his astronomical career in 1908 as an assistant at the Helwan Observatory in Egypt. He took charge of the newly installed 30-in. Reynolds reflector and used it to photograph southern nebulæ as far as south declination 40°. In addition to purely astronomical work, his duties covered the usual scope of a government observatory —time service, gravity survey, geodesy, meteorology and the like. In 1913 Knox-Shaw was made director of the Helwan Observatory, and in 1918 also of the Meteorological Service of Egypt and the Sudan. In 1924 he returned to England to become Radcliffe Observer at Oxford. Two pieces of research in this period are especially noteworthy: the determination of the proper motions of more than 30,000 faint stars in the northern selected areas, and the reduction (in collaboration with Dr. J. Jackson) of the meridian observations of Thomas Hornsby, the first Radcliffe Observer, made between 1774 and 1798. The latter part of Knox-Shaw's term of office as Radcliffe Observer was concerned with the transfer of the Observatory to Pretoria, Union of South Africa, and the erection there of the 74-in. reflecting telescope. This change was successfully carried out in face of a long series of obstacles and delays. Knox-Shaw was president of the Astronomical Society of South Africa during 1941–42, and of the Royal Astronomical Society during 1931–33.

Scientific and Technological Man-power in the United States and the U.S.S.R.

Estimates issued by the National Science Foundation, Washington, D.C., on August 3 give the number of graduates in scientific fields in the United States in 1955 as 59,000, or about 20 per cent of those obtaining first degrees, compared with 126,000 in the

U.S.S.R., or 49 per cent of the total graduates; 22,600 of the former and 59,000 of the latter were in engineering, 2,000 of those in the U.S.S.R. being agricultural engineers. The total number of living graduates with first-level degrees, or their equivalent, in the United States is given as 1,536,000, of whom 575,000 are engineers, and 1,158,000 (555,000 engineers) in the U.S.S.R. In the United States there were, in 1955, 114,600 living Ph.D.s, including 61,800 in science and engineering, and 1,360,000 teachers, of whom 181,000 were working in higher educational establishments, and 130,000–140,000 were teaching science and mathematics in high school. The U.S.S.R. had 80,000–85,000 living persons of Ph.D. level and 9,000–9,500 with advanced doctor's degrees, of whom 60,000–68,000 and 6,000–7,000, respectively, were in science, and 1,900,000 teachers at all levels (120,000 in higher educational establishments and 350,000 science teachers in secondary schools). In the United States 2,721,000 students were enrolled in institutions of higher education and 287,000 first degrees were conferred, of which 9,050 were in biological science, 10,516 in physical science, 7,170 in agriculture and 22,589 in engineering. In the U.S.S.R., 1,865,000 students were enrolled at higher educational establishments, and 265,000 graduated at a level equivalent to a first degree in the United States. Of live holders of first degrees, 566,000 were in engineering and 205,000 in agriculture, 240,000 were science teachers and 87,000 were university graduates in science. Dr. A. J. Waterman, commenting on the danger of making comparisons, except in very broad terms, points out that while in the United States graduates in science may not necessarily be employed in the field in which they were trained, in the Soviet Union they are likely to be so employed.

Employment of Coloured Workers in the Birmingham Area

THE report of an inquiry initiated by the Birmingham Christian Social Council and undertaken by the Race Relations Group of Fircroft College, Birmingham, into the employment of coloured workers in the Birmingham area, has been published by the Institute of Personnel Management as Occasional Paper No. 10 (pp. 30; 1956; 3*s*. 6*d*.). The inquiry was conducted between May 1954 and July 1955, thirty-five places of employment, covering ninety thousand employees and 2,150 coloured workers, being visited. The report, which is written by Leslie Stephens, deals with the background of coloured workers in Britain, including the reasons which bring them here, and whether they are likely to stay, and discusses national differences between West Indians, West Africans and Pakistanis. There are chapters on employment policies, the attitudes of trade unions and British workers, and on the attitudes of coloured workers themselves. Its concluding chapter, which stresses the need for a good deal more information on the actual experiences of coloured workers at work and in trade unions, suggests that the conditions revealed by the inquiry do not give grounds for very grave concern and contain many hopeful elements, although there is undoubtedly some discrimination in the relations of employers and workers to coloured people. Concrete recommendations include the preparation of something in the nature of a Code of Fair Employment for coloured workers or for immigrants in general. More advice should be available to potential employers of coloured workers, and every effort should be made, particularly in the countries of origin, to press on coloured workers their own responsibilities. In every town with appreciable numbers of coloured workers there should be an officer like the liaison officer in the Town Clerk's Department in the City of Birmingham, and an advisory committee with a special concern for the welfare of coloured workers; to increase the effectiveness and raise the level of work of local authorities and voluntary bodies, the Home Office or Colonial Office should be given an overall responsibility for the welfare of coloured people and other immigrants in Great Britain.

Nok Culture of West Africa

THE July issue of *Man* contains a striking illustration of a life-size terra-cotta head in the now familiar Nok style. Bernard Fagg, curator of the museum at Jos, describes the find, which was made in the course of tin mining at Nok itself in southern Zaria Province, Northern Nigeria. The Nok culture is now known to stretch approximately three hundred miles across the Benue-Niger valley from Katsina Ala in Benue Province to Kagara in Niger Province. These artists have made heads that are more beautiful, but few that are as striking as the one here discussed. It must have needed great skill to fire such a large piece with the primitive means at their disposal. The thickness (just under $\frac{1}{2}$ in.) is uniform, and on the top of the head are five bosses probably representing coiled hair. Four of them are pierced, perhaps for the insertion of feathers. Bernard Fagg suggests a date in the first millennium B.C.; but until definite proof from carbon-14 dating comes to hand, there seems little reason why a considerably more recent date might not be postulated.

Underground Storage of Grain

PRIMITIVE methods of the storage of grain in underground pits have been practised in the Middle East for many centuries; but not until 1942, when an experimental underground store was built in the Argentine, was any attempt made to develop the idea along scientific lines. These first trials proved highly successful, and, in spite of the hot and moderately damp climate in which they were carried out, wheat and maize remained in excellent condition for up to seven years. The method has been adopted on quite a large scale in several South American countries, the Argentine now having storage for some two million tons of grain. The possible value of similar systems in British Colonial territories has been under investigation during the past three years, and the results of the inquiry are published in a Colonial Office pamphlet, "Underground Storage of Grain" (Colonial Research Studies No. 21. Pp. 27. London: H.M.S.O., 1956; 2*s*. 6*d*. net). Considerable success has been achieved, and it is hoped to construct pit storage for 11,000 tons in Tanganyika and for 10,000 tons in Cyprus in 1956. The efficiency of underground storage systems depends on the fact that virtually air-tight conditions are achieved. Oxygen is sufficiently depleted, and enough carbon dioxide is produced to inhibit further insect development and often to kill any insects that may be present. No heating of the grain occurs, and external changes of temperature are unimportant owing to the structure of the pit and the large bulk of grain stored. The method has proved cheap and efficient provided the grain is dry (less than 13 per cent moisture), and can now be recommended for the storage of both maize and wheat.

Systematics of the Notostraca

The Notostraca constitute an order of the Euphyllopod Crustacea that is interesting not only because they are examples of primitive Crustacea but also because of their adaptation to life in temporary pools and practically world-wide distribution, and in "A Review of the Notostraca" (*Bull. Brit. Mus.* (*Nat. Hist.*), **3**, No. 1; 1955. Pp. 57; 12*s.* 6*d.*) Alan R. Longhurst has carried out a detailed revision. Careful study of a large amount of material from different countries and museums and from populations reared in the laboratory has shown that a number of the characters that have been used for the erection of species are, in fact, due to differences of age, sex and the number of body segments and appendages as well as the variations that occur naturally in large populations. Only two genera, *Triops* (Apus) and *Lepidurus*, are included in the family and order. Before this revision sixty-nine species and twelve varieties had been included in the order; but Longhurst has reduced that number to nine species and twelve varieties (not the same twelve as previously). The systematic part at the end includes a very clear and straightforward key for the identification of the species of the two genera, and in dealing with each species an indication of the range of variation is given and, where required, the differentiating characters of the varieties. For completeness, this section might have included the name of the family and its definition and definitions of the genera; for example, under *Triops* the only character given is that it is "separable from *Lepidurus* by its lack of a supra-anal plate".

Measurement of High Temperatures by Thermocouples of Noble Metals

The accurate measurement of high temperatures is a matter of prime importance in many branches of science and technology, and, in particular, the greater control made possible by the use of thermocouples of noble metals has contributed materially to the successful development of improved methods in metallurgical industry and research. An interesting, illustrated survey of methods of high-temperature measurement and of the development of the thermocouple in this connexion is given in a new booklet, entitled "Noble Metal Thermocouples", by H. E. Bennett, which has been issued by Johnson, Matthey and Co., Ltd., of London (pp. 36; 1956). Three topics are dealt with separately: applications of the platinum metal thermocouple, with particular reference to its use in the steel industry; the properties of the platinum-group metals and their alloys; and the principal causes of deterioration of thermocouples under the headings of strain, prolonged heating at high temperatures, and contamination. Various physical properties of the platinum-group metals are listed, together with calibration curves for different kinds of platinum alloys/platinum thermocouples. Information is included of results of experiments conducted by the author, and there are many references to work of other investigators. A bibliography of forty-nine references is appended.

British Standards Institution: Annual General Meeting

At the annual general meeting of the British Standards Institution on September 4, it was decided to combine the two formerly separate offices of president and of chairman of the General Council. Sir Herbert Manzoni (City Engineer of Birmingham), who is already chairman of Council, was elected the first president under this new arrangement. He succeeds Sir Roger Duncalfe, chairman of British Glues and Chemicals Ltd., who has served the Institution in many offices for the past twenty years. Mr. John Ryan (vice-chairman of the Metal Box Co., Ltd.) was re-elected vice-president. The following were elected, as representatives of the Institution's divisional councils, to serve on the General Council: *Building Division:* Mr. H. A. Pursey (Turners Asbestos Cement Co., Ltd.); Mr. J. C. Tait (Department of Health for Scotland); and Lieut.-Col. E. Vigor (Neuchatel Asphalte Co., Ltd.); *Chemical Division:* Mr. G. J. Cutbush (Metropolitan Leather Co., Ltd.); Mr. G. Dring (Bakelite, Ltd.); and Sir Knowles Edge (W. Edge and Sons, Ltd.); *Engineering Division:* Mr. P. L. Jones (Swan Hunter and Wigham Richardson, Ltd.); Mr. G. L. Newman (Metropolitan-Vickers Electrical Co., Ltd.); and Mr. B. E. A. Vigers (Laporte Industries, Ltd.); *Textile Division:* Mr. H. N. Aitken (British Celanese, Ltd.); Mr. L. F. Cockroft (John Cockroft and Sons, Ltd.); Mr. P. W. Gaddum (H. T. Gaddum and Co., Ltd.); and Mr. E. R. West (Jute Industries, Ltd.).

National Smoke Abatement Society

The annual conference of the National Smoke Abatement Society will be held in Southport during October 3–5. The programme will include an address by Mr. Enoch Powell, Parliamentary Secretary to the Minister of Housing and Local Government, on the new Clean Air Act, and a session devoted to the Act from the point of view of local authorities. Other subjects to be discussed are the health aspects of the problem, pollution from road vehicles and problems of increasing the supply of solid smokeless fuels for use in smokeless zones and the new smoke control areas. The Des Voeux Memorial Lecture this year will be given by Sir Hugh Beaver, who will speak on "Clean Air: the Next Step". A resolution authorizing a special general meeting in the near future for the purpose of revising the Society's constitution and changing its name to the "National Clean Air Society" is to be considered. Further information can be obtained from the Society at Palace Chambers, Bridge Street, London, S.W.1.

British Institution of Radio Engineers: Awards

The British Institution of Radio Engineers has recently awarded the following premiums for papers published in its *Journal* during 1955: *Clerk Maxwell Premium* (the senior premium for the most outstanding paper in the *Journal*), to E. M. Bradley and Dr. D. H. Pringle (the theory and design of gas-discharge microwave attenuators); *Heinrich Hertz Premium*, to Dr. R. Filipowsky (electrical pulse communication systems); *Louis Sterling Premium*, to D. R. Coleman, D. Allanson and B. A. Horlock (the development and design of an underwater television camera); *Marconi Premium*, to Dr. Sin-Pih Fan (the magnetron beam-switching tube: its operation and circuit design criteria); and *Leslie McMichael Premium*, to D. J. Fewings and S. L. Fife (a survey of tuner designs for multi-channel television reception).

Courtaulds' Scientific and Educational Trust Fund: Postgraduate Research Scholarships for 1956

The Courtaulds' Scientific and Educational Trust Fund has recently announced the award of postgraduate research scholarships for 1956. Scholarships in a branch of science related to the textile, plastics

and allied industries (maximum of £400 for one year only, but renewable for further periods) have been awarded to the following: E. W. Abel, Northern Polytechnic, London; Miss P. A. Carr, Imperial College of Science and Technology, London; G. Holden, University of Manchester (renewal); W. A. Keith, The Queen's University, Belfast; and M. T. Pope, University of Oxford (renewal). Postgraduate research scholarships in textile technology, tenable for two years (£320 the first year and £360 the second), have been awarded to the following: B. Chalkley, J. D. Johnson, W. G. Kaye (renewal), A. P. Lockett, D. W. Martin, Miss A. J. Soper, P. E. Williams and E. R. Wyke. The holders of these scholarships have all chosen to do their research at the University of Leeds, except Mr. Lockett, who will work at the Manchester College of Technology.

Oversea Service Division, Colonial Office

THE following appointments have recently been made in the Oversea Service Division, Colonial Office: J. C. Collins (chief tobacco adviser, Northern Rhodesia), senior agricultural officer (tobacco), Uganda; H. A. L. Francis (assistant agricultural superintendent, Dominica), agricultural superintendent, Dominica; J. S. Gunn (agricultural officer, Tanganyika), senior agronomist, West African Institute for Oil Palm Research; R. R. Mason (agricultural officer, Fiji), senior agricultural officer, British Solomon Islands Protectorate; W. V. Rose (deputy director of agriculture, Barbados), assistant director of agriculture, Western Region, Nigeria; Song Thian Siang (senior agricultural assistant, Sarawak), sub-assistant agricultural officer, Sarawak; E. R. Watts (rural education officer, Western Region, Nigeria), agricultural officer, Western Region, Nigeria; A. J. Radford (government chemist, Mauritius), geochemist, Geological Survey Department, Tanganyika; C. W. C. Turner (vice-principal) and J. R. Scobie (lecturer in mathematics), to be principal and vice-principal respectively of the Yaba Technical Institute, Federation of Nigeria; R. J. Dewar (assistant conservator of forests, Nyasaland), deputy conservator of forests, Nyasaland; J. S. Smith (conservator of forests, grade A, Federation of Malaya), deputy director of forestry, Federation of Malaya; R. C. Pargeter (senior geologist, Geological Survey Department, Uganda), senior geologist, Geological Survey Department, Federation of Nigeria; Dr. T. Wilson (senior medical research officer, Federation of Malaya), director of the Institute for Medical Research, Federation of Malaya; R. Mather (meteorological officer, Malayan Meteorological Service, Singapore), assistant director, Malayan Meteorological Service, Singapore; J. B. D. Robinson (scientific officer, Kenya), senior scientific officer, Kenya; J. D. Bald (assistant surveyor, Forest Department, Kenya), staff surveyor, Forest Department, Kenya; B. N. Bowden, specialist officer (ecologist), Northern Region, Nigeria; L. H. Collett, soil conservation officer, Barbados; R. I. Green, agricultural officer (soil conservation), Nyasaland; J. F. Harrop, soil survey officer, Uganda; T. G. Stephen, agricultural officer, Gold Coast; P. Blasdale, entomologist, Tsetse Control, Northern Region, Nigeria; C. A. R. Savory, biologist (game officer), Northern Rhodesia; D. Adair, chemist, Leeward Islands; W. R. Day, forest pathologist, Cyprus; F. Endean and K. A. Jenkins, assistant conservators of forests, Northern Rhodesia; J. F. Harris, geologist (mining), Geological Survey Department, Tanganyika; W. A. Fairburn and D. J. Jennings, geologists, Kenya; S. L. Edwards, statistician, East Africa High Commission; J. G. Hare, veterinary officer, Kenya.

Announcements

AT the annual general meeting of the Manchester Literary and Philosophical Society the following officers were elected: *President*, Dr. F. C. Toy; *Vice-Presidents*, Miss A. C. Alexander, Sir Geoffrey Jefferson, Prof. J. Kenner, Dr. Norman Smith; *Hon. Secretaries*, Dr. L. Cohen and F. Willett; *Hon. Treasurer*, H. Hayhurst; *Hon. Librarians*, Dr. W. H. Brindley and P. G. Lucas; *Hon. Curator*, N. G. C. Pearson.

A SYMPOSIUM on the "Direction of Research Establishments" is to be held at the National Physical Laboratory, Teddington, during September 26–29. Among the speakers will be the directors of research establishments in Holland, Western Germany, Canada and the United States as well as Great Britain. Papers and summaries of the discussions are to be published as soon as possible by H.M. Stationery Office. Further particulars about the symposium can be obtained from the Secretary, Department of Scientific and Industrial Research, Charles House, 5–11 Regent Street, London, S.W.1.

WITH the current year, the *Bibliography of Scientific Publications of South and South-East Asia* is being issued as a priced publication, the annual subscription for four quarterly numbers, of which that for April 1956 is No. 1 of Vol. 2, being Rs. 10. The 1955 volume is also being issued as a single number at the same price. An author index is included with each quarterly part.

THE National Institute of Technology, Rio de Janeiro, has published the first part of a "Bibliografia Brasileira de Química Tecnológica" (1, No. 1; 1954; pp. 153), which has recently been received. It contains references to, and short abstracts of, publications on various branches of chemical technology which have appeared in Brazil during the years 1922–53. These are classified under subjects according to the universal decimal system adopted by the British Standards Institution.

THE Chilean Iodine Educational Bureau (Stone House, Bishopsgate, London, E.C.2) has published a book, "Geochemistry of Iodine" (pp. 150; n.p.), which contains an annotated bibliography from 1825 to 1954 and covers publications on the occurrence of iodine in rocks, minerals and soils, as well as flue dusts, meteorites, iron and steel. The occurrence of iodine in waters and the atmosphere is to be dealt with in a later publication. The book is well arranged and is strongly bound in cloth.

SOLUS-SCHALL, LTD., a firm engaged in the whole field of non-destructive testing, has recently started a "Newsletter" in which brief information is given of new equipment available, new techniques and recent results obtained. Issues will be dispatched free at intervals to all interested. The first number (January 1956) contains brief discussions of the non-destructive testing of welds and of the appropriate spheres of use of X-rays and gamma-rays in industrial radiography. There are numerous half-tone illustrations of apparatus, including an ultrasonic flaw-locating rule, a portable radiation meter suitable for radiation monitoring and as a liquid level gauge, and arrangements for fluorescent X-ray analysis and flash radiography.

APPLIED RESEARCH AND DEVELOPMENT WITHIN THE INDUSTRIAL GROUP OF THE U.K. ATOMIC ENERGY AUTHORITY

By L. ROTHERHAM* and Dr. A. B. McINTOSH†
Industrial Group, U.K. Atomic Energy Authority

WE have previously described[1] the general organization developed for the control of applied research and development within the Industrial Group of the United Kingdom Atomic Energy Authority to provide a development effort for all sanctioned construction projects. The system of organization developed must be integrated with a type of executive management which gives the means of firm direction and control while preserving scientific integrity.

In general terms, the main executive responsibility lies in instituting a type of management which enables a strategic plan of research to be tactically discharged with the necessary standard of scientific and technical excellence. The preparation of appropriate financial and staff estimates, and the maintenance of all records necessary to the forward planning of experimental effort and the periodic reviewing of progress, are essential features.

Allocation of Priorities

The work of the experimental establishments serves both the Engineering and Operations Branches[1]. Broadly, where subject priorities are concerned, it is agreed that existing processes must be kept working before all else; secondly, sanctioned projects must be introduced on time, and thirdly, modifications and refinements recognized as advisable should be added to existing projects as facilities permit. A system of priority classification has been designed to take account of both the subject priority and the latest date before action must be taken by either the Engineering or Operations Branch. Some target dates are irrevocable and must be met; others, if necessary, can be revised as a result of due consideration. Based on an analysis of this sort a decreasing scale of priority can be worked out which introduces the time available for experimental work. Where the importance of the subject justifies it, work required within six months merits the highest priority, for which staff will be made available over all other types of work. The time available for second priority work is arbitrarily fixed, and for third priority work no completion date need be stated.

Some general principle must be accepted for assessing priorities, and those set out above are suitable for some circumstances. The principles must be in conformity with the financial and administrative arrangements, and if this is the case, although they may be arrived at arbitrarily, they can safely be adhered to as a working arrangement. It is useless, however, to have a system of assessing priorities and then to ignore the conclusions reached.

Allocation of Costs

The assessment of priorities provides a convenient method of division into categories so that the costs can be properly allocated.

The cost of development work carried out on behalf of the Operations Branch for the removal of difficulties in, or improvement of, existing processes is borne by the works and recovered as a charge on the finished products. Such investigations, always of a high priority, are undertaken only at the request of, or by agreement with, the works general managers, but are never delayed by excessive formality.

The major amount of research and development effort is allocated to work in support of current sanctioned design commitments, and, for such, the charges are borne by the chief engineer of the project. These charges are recovered by an addition to capital charges which are amortized over a period of years. In this category the nature of the problems and the necessary experimental work are discussed thoroughly by the chief engineer, head of the experimental establishment and chief scientist[1], following which an estimate of the cost is returned to the chief engineer without delay so that he can assess whether the cost is in proportion to his need. If he feels that the expenditure is too great and that some engineering solution is both possible and preferable, the nature of the problem will be reconsidered against the general background of reactor development and, if the work is undertaken, it will be as a research and development charge. All long-term research and all work for feasibility and design studies of projects not yet sanctioned are Research and Development Branch[1] charges. Work of this type is carried out by the Research and Development Branch without prior discussion with other branches.

Work Requisition and Initiation Procedure

The implementation of the priority and cost allocation procedure leads to a system of work requisition and initiation designed to ensure that only work is undertaken which is expected to influence the course of development and to prevent the application of effort in directions which, although interesting, would be less profitable. A standard requisition form is the medium by which requests for work are passed from headquarters to the laboratories, or from the laboratories to each other or to headquarters, and copies are sent to any other interested parties. This outlines generally the nature of the problem and gives a brief description of the background to the investigation.

On receipt of the requisition the establishment responsible for meeting the requirements decides the reporting dates, and issues an instruction sheet to appropriate sections. There are cases where reporting dates must be imposed in the requisition to fit in to a programme approved by the Research Board, or to conform to some key design date. In such cases the reason for this is stated in the "Background to the Investigation". If the requisitioned laboratory, in view of its existing commitments, is unable to meet these dates, advice on relative priorities may be obtained from the functional chief scientists, or reference may be made to the Research Board[1].

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Obviously, any system for requisitioning work or for the initiation of new items of work must not interpose delays. This is avoided by an adequate delegation of authority. The head of each experimental establishment is responsible for the use of his staff. He can start work himself, to a cost of £500–£1,000, without reference to anyone. If larger sums are involved, by discussion with other heads of experimental establishments, chief scientists or the director, work can again be initiated without any formality. Afterwards, instruction sheets, requisitions and cost returns will be prepared. Periodic reviews of progress may also be made to see if the original instructions need amendment.

Planning of Experimental Effort

Accurate planning of scientific and experimental effort ultimately depends on accurate records of effort spent on previous comparable work.

The effort available from each person in a particular period is reckoned as the number of normal working days less an average figure computed from his annual leave allowance and other absences. The number of investigations which can be efficiently worked on decreases as the status of the staff decreases. Excessive diversification is undesirable, and when it occurs the research manager, in consultation with the section leader, decides how many days will be devoted to each job. If the estimates of time allocation are realistic, over-planning indicates that overtime should be temporarily worked, and that for the long term, additional staff or reduction in the number of commitments should be recommended. Conversely, under-planning implies that additional commitments can be accepted or staff can be available for transfer.

The main experimental work must be supported by services from chemical analysis, X-ray crystallography, metallography, etc. The indirect effort involved is more difficult to estimate. When adequate records are available, these will indicate the amount of indirect effort appropriate to the type of investigation involved. To integrate this with the main effort so that the latter is not delayed may present such difficulty that the best solution may be to make an arbitrary allocation of service effort to any particular section, leaving it as the section leader's responsibility to utilize this allocation to meet his priorities.

Staff can only be provided without delay if there is spare capacity, which is rarely the case. Normally all staff are fully occupied and examination is made of the priorities of work in hand to see which jobs can best yield staff to the proposed new one, if this is of higher priority. When this fails, target dates for all work show the earliest date on which staff will be available. New recruitment is regarded as an aspect of long-term planning and seldom enters into decisions related to work to be undertaken in the immediate future. It may be necessary to refer the matter to the Research Board to resolve competing priorities or to agree on alternative measures for obtaining experimental capacity.

Costing of Experimental Work

In the compilation of an instruction sheet, the estimated amount of experimental effort is stated in terms of the grades of staff to be used. Scientific and experimental staff fall into the three categories of senior, main, and assistant grades. Taking an average figure for the salaries of the staff, and a factor computed by the accounts branch from all other normal expenses, the cost of any investigation can be calculated from the instruction sheet. If a second instruction sheet arises from the first, the cost of the second would be an abnormal charge on the first. Similarly, abnormal usage of any particularly expensive item (for example, a rare metal) necessary to some job is clearly indicated on the instruction sheet, so that a particularly heavy charge is carried by the specific job.

The estimates of the scientific effort required for a particular job are compared with the actual returns of effort spent. The basic information is obtained from the sections by weekly returns of the effort of staff against the various jobs. These returns are forwarded to the Accounts Branch and are the basis of the cost figures produced by them relevant to each job on the programme. These cost figures are tabled at each meeting of the Research Board and explanations made of significant deviation from the estimates. The cost of any job is thus currently known at every stage so that its economic value to the project can be kept under constant review.

Management

The management structure of each research and development establishment is similar and is based on definite responsibilities. The success with which an establishment is managed is clearly the responsibility of its head, who is the administrative authority responsible for ensuring that the work conforms to the policy and commitments of the Branch. The management proper of the scientific work falls to research managers, the number of whom varies with the size of laboratory. Generally, each will be responsible for the work of a group of between thirty and forty scientific and experimental workers. The distribution of scientific, engineering and experimental strength varies, depending on the type of work. Where the work has a highly scientific character, the ratio of experimental to scientific workers will approach 1. Where the work is highly repetitive, the ratio may exceed 5. To preserve a career prospect within the scientific class, it is recognized that any number settled as a complement may ultimately reach 50 per cent of the highest grade below that of research manager. To ensure that the earliest possible recognition is given to merit, staff reviews are held twice yearly to a common standard throughout the Authority, at which all eligible staff are considered. The principle of recognizing ability and giving responsibility leads to the early promotion of suitable staff.

The head of the establishment retains the responsibility of ensuring that the method of approach to any problem is selected on valid scientific grounds to yield the information required. It is the research manager's responsibility to see that a high scientific standard is maintained in the laboratories. The head of the establishment, through the planning and progress officer, ensures that the necessary reviews are forthcoming to plan, and that they conform to the required standard.

On receipt of an instruction sheet the section leader must plan his work. The first requirement is to isolate the problem requiring attention, so as to avoid unnecessary investigation. Having first done this and then consulted the literature, he must plan the experimental attack. It is particularly important that he compile an equipment schedule indicating the dates when he requires instruments. All instruments are entered on an equipment register which at

any moment indicates the job number on which an instrument is being used and the section where it is located. Any instrument not on a job number must be returned to the equipment store. Only by a procedure of this sort can the best use of instruments be assured within any one of the establishments or throughout the whole branch. For the latter purpose a Branch Equipment Register is held of all plant and equipment in the five Laboratories.

Reporting of Work

All work must be reported in one of the Branch's three recognized documents. The overall general structure and form of reports is agreed at the Research Board and is standardized for the Branch.

A 'technical memorandum' quotes factually the results of experiment and gives no opinions or recommendations. No special vetting procedure is necessary to ensure conformity to policy; but each memorandum must be addressed for the attention of an individual or body whose query prompted the exercise, or who can take any consequent executive action.

A 'technical note' gives the results of an investigation required to settle some point of policy or design. Conclusions are reached and recommendations made to guide further policy or design decisions. All technical notes are addressed for the attention of one of the Authority's recognized committees, or working parties. Technical notes likely to influence the policy of the Branch, either in respect of the prosecution of work within it or of the attitude which it will adopt to some proposal arising from other groups or branches, are addressed for the attention of the Research Board. Because of the influence that any technical note can have on policy or design involving the expenditure of large funds, it is the head of the Establishment's responsibility to ensure that the note has been properly vetted.

A full 'report' has all the requirements of a technical note with the addition that it deals with a completed block of work. It should be of the standard of a paper to a learned society.

The experimental worker is of course responsible for reporting on his own work, but his draft is subject to scrutiny particularly in regard to its general form. The section leader ensures that all experimental facts and observations have been used in the compilation, and the research manager makes any necessary comment as a result of his wider knowledge and experience. Full reports and technical notes before issue are finally approved by the head of the Establishment, who must be responsible ultimately for the quality of work from his own laboratory.

Distribution of all papers is subject to a number of provisions, depending on the status of the document in regard to its classification. The minimum standard distribution is agreed by the Research Board for each type of document, and additional distribution requires special authorization, depending on the category.

Conclusions

Particularly with applied research, the best work is based on the maximum of meticulous observation with scientific analysis of the results. Observations are amenable to timing and therefore to planning. The inspiration so necessary to the forward development comes to those suitably endowed, with or without a declared plan.

Scientific staff may fail to understand the need for, and therefore resent, the passage of paper and forms between one office and another. This is almost invariably a sign of bad management. The forms are not used as a discipline of the scientific staff but as a means of passing necessary information between the various sections which are concerned. Applied research is almost always a team endeavour involving many different skills, and it is a convenience to introduce a measure of formality into the administration, provided it is under broad-minded control. The formal organization of the scheme must not involve the scientific staff in more than a minimum of administrative work, and they should recognize it as reasonable. They must be allowed to make the proper use of their intellectual abilities without the need to digress every few days to consider administration. In each establishment a technical planning officer and administration officer with clerical assistance are quite sufficient to administer a scheme such as has been outlined.

It must be clear that in giving this outline of some of the methods used, we have not attempted to give a full picture. Only an indication has been given of the administrative and financial framework within which the scientific work can be carried out. It is pointless to construct such a framework and then not to use it; but its use must be, on every occasion, conditioned by the thought that the ultimate criterion of success of a research and development department is in the scientific and technical quality of the work done. The scientific staff must feel that the framework is provided to assist them in their work and not to divert them by form filling, committee attendances and so on.

During the period in which the development of the system of organization and management has taken place, opportunity has arisen to observe the reaction of the scientific staff. In general, scientific staff with experience of the system favour the control which it imposes, although about 1 per cent of recruits are unable or unwilling to work when so controlled. The main requirement is that in any establishment the system of organization must be devised by scientists and be acceptable to them.

In the development of this type of organization, responsibility has been given to all members of staff capable of accepting it. This has bred a responsible approach at a remarkably early age.

[1] *Nature*, 178, 524 (1956).

SOCIETY FOR APPLIED BACTERIOLOGY

SUMMER CONFERENCE

MILK and cheese were the main, but not exclusive, topics discussed at the summer conference of the Society for Applied Bacteriology held in Reading during July 16–18. Several of the papers contributed were by members from the University of Reading and from the National Institute for Research in Dairying, Shinfield.

One of the first papers dealing with milk was by D. J. Williams, J. G. Franklin, Miss H. R. Chapman and L. F. L. Clegg (Shinfield), who described a method for assessing the sporicidal efficiency of ultra-high-temperature sterilization. Membrane filters are used for detecting trace contaminations in the large

volumes of milk employed. By adjusting the inoculum of bacterial spores appropriately, this technique allows killing-rates of more than 99·99 per cent to be assessed.

Consideration was given by D. G. Griffiths, R. G. Druce and S. B. Thomas (Aberystwyth) to the present microbiological standards and tolerances for raw milks, some of which, they suggested, should be tightened in view of the continuous improvements taking place in the methods of handling, storing and sampling milks on the farm. They thought that the present methods of testing should be retained, but that satisfactory milks should not have a total count exceeding 20,000 organisms per ml. and the V.R.B. coli-aerogenes content should be less than 10 per ml. J. G. Murray (Belfast) compared the coli-aerogenes test at 30° C. with that at 37°, using raw and pasteurized milks, and obtained no false presumptive results in three thousand samples examined. Of the pasteurized samples examined, 33 per cent were positive at 37°, and 67 per cent were positive at 30° but negative at 37°; of the raw milks, the comparative values were 76 per cent and 24 per cent. Bottles and dairy equipment gave similar results, but not dried milks.

Prof. E. L. Crossley and Miss M. Campling (Reading) described their investigations into the survival of *Staphylococcus aureus* in the production of spray-dried milk, in which they demonstrated undoubted proliferation during bulk storage, but a tendency for a decline in numbers during the evaporation stage. The survival-rates of four strains on spray-drying ranged between 0·25 and 3·5 per cent; such values are inexplicably lower than those reported earlier. It was thought that organisms picked up after the evaporation stage were likely to cause most trouble because of their capacity for selective growth.

Turning to the bacteriology of cheese, Miss M. E. Sharpe and Miss J. Naylor (Shinfield) commented on the desirability of adding bacteria to maintain particular flavours, and emphasized the importance of the starter in this respect. They examined the survival of lactic bacteria in Cheddar cheeses over periods up to six months and found that the streptococcal types declined in number but the lactobacilli grew slightly. Of the three media used for isolating the various types, acetate agar was best for the lactobacilli. In a similar vein, and on the assumption that farm-house cheeses have a better flavour than factory-made cheeses because they are made under less rigorously controlled conditions and with less pure cultures, Miss N. J. Hall (Reading) examined the associated growths of *Streptococcus lactis*, an organism found normally in cheese, and *Escherichia coli*, a potential common contaminant. Mixed cultures added to the cheese vats undoubtedly affected the flavours according to the amounts of the cultures used, and fortunately the *E. coli* always died out. In mixed cultures maintained in continuous daily subculture at 30° and 37°, *E. coli* disappeared in a few days, and it was not detected in cheese a few weeks after manufacture. The influence of rennet on bacteriophage multiplication in milk prior to making cheese was discussed by L. J. Meanwell and Miss N. Thompson (London). They found that rennet added to milk within 30 min. of inoculating with a starter culture protects the culture against phage attack by stimulating cell production and suppressing phage multiplication. This prolongs the time before phage numbers equal cell numbers and so allows acid production to continue for some hours.

H. B. Hawley (Yeovil) gave two papers, one of which was in collaboration with G. Bourne (London), on the bacteriological deterioration of processed cheese, and its micro-structure and fat distribution. The papers were well illustrated by slides which clearly demonstrated the effects of different contaminating bacteria on the appearance of the cheese, such as 'eyes' in Cheddar cheese due to propionic acid bacteria and deformation in packet cheeses due to bacterial spores. Histologically, the micro-structure has many resemblances to pathological specimens, and bacteria can be seen associated with the fat globules.

Having disposed of the papers on milk and cheese, the conference heard M. Lev and C. A. E. Briggs (Shinfield) describe their investigations into the establishment of the gut flora in the newly hatched chick. Somewhat surprisingly, they found a balanced flora to be present after two days, and even after 24 hr. the broad groupings are established. Highest counts are found in the cæcum, and the next highest in the crop.

The effect of various detergents on the activities of a number of quaternary ammonium compounds at different temperatures and in waters of different hardness was the subject of a paper by Miss C. M. Cousins and L. F. L. Clegg (Shinfield). In general, lower temperatures meant lower activities, although the temperature coefficients varied with the compounds. Water hardness was very significant, to the extent that a mixture active at 50 p.p.m. in distilled water may not be completely effective in a hard water at 200 p.p.m. The activity of the quaternaries themselves bore little relation to their activities in detergent mixtures.

Another topic discussed was the preservation of organisms of the *Pseudomonas* type under mineral oil. Miss M. E. Rhodes (Reading) emphasized the need for cultures to be totally sealed with the oil to effect preservation and described it as an improved method because only slight changes occurred in the saccharolytic and proteolytic properties of the cultures so treated. She preferred it to freeze-drying. Of 170 organisms examined, only 6 per cent changed their reactions to sucrose and 2 per cent to galactose, whereas those maintained in continuous culture underwent significant changes. W. B. Hugo (Nottingham) described a new, or rediscovered, *Pseudomonas* species which is very similar to, or identical with, *Ps. lemonnieri*. It occurred as a contaminant and was singled out for investigation because it produces a characteristic blue pigment which is different from pyocyanin as shown by ultra-violet absorption spectra. The pigment is protein in nature, insoluble in water, and is only produced aerobically in the presence of carbohydrates.

The last two papers dealt, in effect, with the systems of classification of organisms. S. T. Cowan (Colindale) discussed the biochemical and other characteristics of various members of the coli-aerogenes group of bacteria, showing how irregular are some of the divisions of the different genera. This was illustrated by examples such as *Klebsiella pneumoniae*, *Kl. aerogenes*, *Cloaca* and *Citrobacter* spp. He pointed out that any system of nomenclature depends on the system of classification used, and added that utility is another factor to be considered. In a similar way, Joan Taylor (Colindale) discussed a subject on which opinions have varied from time to time, namely, the pathogenicity of *E. coli*. This organism as an infective agent is essentially

confined to babies three to six months old. It is infectious in close communities; but the same serotypes are found universally. These serotypes may differ slightly in their biochemical characteristics; but fundamentally they are all typical *E. coli*. At the same time, they may have serological identities with certain of the *Salmonella* group. So what of their classification?

These papers will be published in full at a later date in the *Journal of Applied Bacteriology*.

INTERNATIONAL LIGHT METALS CONGRESS AT LEOBEN

THE international Light Metals Congress, held in Leoben, Austria, during June 7–9, was the third such meeting there, the previous ones being in 1934 and 1948, and as on the former occasions, the purpose of the Congress was to give a comprehensive picture of the present state of the light metals industry and to permit informal discussion and exchange of views among the delegates. Organized by the Montanistische Hochschule with the assistance of the Austrian light metals industry, the Congress was attended by more than three hundred and fifty representatives from nineteen countries. The programme included an exhibition of the applications of aluminium, various visits and social functions, and six technical sessions at which more than thirty papers were read. In addition to the usual facilities for lantern slides and films, arrangements were made for the whole proceedings to be televised to a second audience in the overflow meetings.

The opening session was devoted to reviewing the part played by light metals in the economy of the major countries represented, which included Austria, France, Great Britain and the British Commonwealth, Italy, the German Federal Republic, Switzerland and the United States. The papers were contributed by W. C. Binz, R. Carmina, Th. Dirksen, A. Dumas, F. C. Frary, B. K. Klein, G. V. Schulthess and W. J. Thomas, respectively. All told much the same story of rapid post-war growth of the industry, encouraged by the continuing strong demand for light metal products. An interesting fact brought out by these papers is that the present and estimated future demand for aluminium exceeds existing supplies of electrical energy and bauxite—the chief raw materials of the industry—so that attention is being turned to additional sources, notably those in undeveloped areas of western Canada and Africa.

In the session dealing with advances in metallurgy, M. O. Sem (Oslo) described the importance of the Söderberg electrode in modern large electrolytic cells, and P. Gross (Stoke Poges) examined the conditions to be fulfilled in the sub-halide distillation of aluminium. A. Brenner (Lend) gave an account of the production, properties and uses of super-purity aluminium—a material which is of growing industrial importance. The single paper devoted to magnesium was presented by C. J. P. Ball (London); this was a comparative survey of the methods currently used for the extraction of magnesium.

Interest in titanium, the latest member of the light metals family to be used industrially, was evidenced by the five papers dealing with this metal. Two of these described extraction processes: R. Kieffer (Reutte) summarized the present methods of production, with figures illustrating the astonishing growth in output during the past few years, and E. Fitzer, H. Hofbauer and H. Hohn gave an account of a process in which an alkali amalgam is used to reduce titanium tetrachloride to titanium amalgam, the mercury being afterwards removed by distillation. M. Hansen (Frankfurt) dealt with the physical metallurgy of titanium and its alloys.

An encouraging sign of improved international relations was the participation of scientists from the U.S.S.R., who contributed two papers on the metallurgy of titanium alloys, including one by Dr. M. A. Pavlov, of the Moscow Academy of Sciences.

Papers dealing with the technology of light metals included one on foundry practice by Prof. A. von Zeerleder, a pioneer of the light metals industry, who discussed the advances in foundry technique from the historical point of view, with emphasis on recent improvements in gating systems. K. Schneider (Nuremberg) described the methods used in the recovery and treatment of secondary metals, and M. Lamourdedieu (Paris) dealt with current practice in the rolling of light metals. Much interest was aroused by R. D. Hamer's paper on experience with the continuous casting and rolling of aluminium strip, which was supported by a short film depicting the operation of installations at Rorschach and Banbury. During recent years a demand has arisen from the aircraft industry for large structural forgings to replace members which otherwise would be built up from extrusions and sheet, and G. W. Richards and C. Wilson (Birmingham) discussed some of the metallurgical problems which arise in the production of these forgings, particularly the control of internal stresses. An account of recent advances in welding practice, including inert gas welding, cold welding and the high-frequency welding of tubes, was given by E. Zurbrügg (Neuhausen), and G. Luft and F. Sacchi (Novara) read a paper on surface treatment with reference to Italian experience.

Six papers were devoted to topics in physical metallurgy and metallography. R. Mitsche (Leoben) described the effect of superheating on the structure of as-cast metals, while E. M. Onitsch-Modl (Winterthur) surveyed the powder metallurgy of aluminium, magnesium and titanium. P. Brenner (Lend) discussed an urgent engineering problem, that of the fatigue strength of aluminium alloys and its relation to other properties of the material. The connexion between processing conditions and the properties of extrusions was considered by E. Nachtigall (Ranshofen), and G. Siebel (Singen) discussed a perennial production problem—the earing of certain aluminium alloys during deep drawing and the influence of processing variables on this behaviour. E. Schmid (Vienna) contributed a necessarily brief account of the part played by lithium, beryllium, magnesium, aluminium, silicon and titanium in certain applications to physics, with particular reference to nuclear energy.

The final session was devoted to applications of the light metals. The way in which new applications are evolved, developed and finally established was discussed by de Ridder, and M. Langegger (Ranshofen) described the various applications of semi-finished products in Austria. L. Kirste (Vienna) examined the essential requirements to be met for successful light-weight construction, and C. Panseri (Novara) mentioned some of the problems which arise when aluminium is used in architecture; he also described a new magnesium-silicide alloy which has been developed in Italy for spandrel sections. A

comprehensive paper on the use of aluminium for transport by land, sea and air was contributed by J. J. Baron (Paris), in which details were given of the various applications. A. Taranger (Oslo) discussed another field of use, that of rigid wall cans for processed foods; he concluded that the technical obstacles to the use of aluminium in canning have been largely overcome, and therefore wider employment is a matter of economics. J. C. Bailey (London) dealt with electrical engineering, a field in which aluminium has made, and is still making, great strides and in which it occupies a favourable economic position.

In addition to the foregoing, the following papers were submitted in summary form: improvements in the quality of aluminium–silicon alloys (W. Thury); reactivity and specific consumption of anode carbon in the industrial electrolytic production of aluminium (A. Vajna de Pava); and chemical background to the wet alkaline process of Bayer for extracting aluminium oxide hydrate from bauxites (F. Heyd).

The full text of all the papers will be published, in German, in the journals *Aluminium* (Aluminium-Verlag GmbH., Düsseldorf) and *Berg- und Hüttenmännischen Monatsheften* (Springer-Verlag, Vienna) this autumn.

THE MEDICAL RESEARCH COUNCIL
REPORT FOR 1954–55

THE report of the Medical Research Council for the year 1954–55* follows the plan used in recent years of giving summaries only of the work of the Council's many research establishments, the main part of the report being devoted to a discussion of selected aspects of the general trend of medical research. As the report emphasizes, every conspicuous advance in medical research depends on a mass of unspectacular work and on team work, to which every individual taking part, whatever his status, contributes essential skill or knowledge.

Among the subjects selected for discussion this year the control of poliomyelitis is of popular interest, and an account is given of the vaccines now in use as prophylactics against this disease. The results of the American trial of the Salk vaccine, so admirably conducted, showed that this vaccine reduced paralytic poliomyelitis among children aged 6–9 years by 28 per cent, the protection increasing with age. After revision of the safety tests, many millions of children in the United States and Canada have been vaccinated. The report describes the work being done in Britain on the manufacture of a somewhat different vaccine and on tests of its safety and on trials of it. It then goes on to discuss the epidemiology of poliomyelitis and the increased risk of development of the disease in children who have recently been inoculated with a combined prophylactic against diphtheria and whooping-cough or who have recently had their tonsils removed.

Other subjects discussed in this part of the report are recent research on influenza, vaccination against tuberculosis, antibody immunity, the mechanism of allergic reactions, the causes and control of œdema due to diseases of the kidneys, human genetics, developments in biophysics and the fallacies of the design of industrial work.

* Committee of Privy Council for Medical Research. Report of the Medical Research Council for the Year 1954–55. (Cmd. 9787.) Pp. v+286. (London: H.M.S.O., 1956.) 10*s.* net.

The rest of the report, after outlining the administration of the Council's work, epitomizes its research programme and gives the names of its personnel, summaries of the programmes of the many research units and a list of the many publications reporting the work of the Council's staff and the work of the staffs of the Institute of Cancer Research and the Public Health Laboratory Service. The report is, in fact, a complete guide to the Council's many-sided activities. It would be hard to find anywhere a finer record of the devoted efforts of many people of different skills to better the health of man to-day and to make the world a better place for generations to come.

G. LAPAGE

CRYSTALLINE CYTOCHROME C
Preparation of Crystalline Cytochrome c from Yeast

THE first crystallization of cytochrome *c* was reported from muscle of the king penguin by G. Bodo[1]. Cytochrome *c* has been crystallized by us from more convenient sources, such as baker's yeast, beef heart[2] or pig heart[3]. In this communication is reported the isolation from yeast of crystalline cytochrome *c*, which was shown to be a homogeneous protein by electrophoretic, ultracentrifugal and chromatographic criteria[3].

Baker's yeast, treated with ethylacetate (1/7 vol.) for one hour, was twice washed by suspending in tap water (5 vol.) for one hour while keeping the suspension at *p*H 7–8 with ammonia. The washed yeast was twice extracted with 10 per cent ammonium sulphate solution (the same volume as the yeast cake) for fifteen hours. The ratio of extinction at 550 mμ of the reduced pigment to the extinction of 280 mμ of oxidized pigment which is abbreviated to R_{280}^{550} was 0·01. The extract, after being dialysed against tap water for two days, was passed through a column of cation exchange resin, 'Duolite *CS*-101' (buffered at *p*H 7·0), which has a greater capacity for adsorption of cytochrome *c* than the 'Amberlite' *IRC*-50 (*XE*-64) ordinarily used[3–5]. After washing the column with dilute ammonium sulphate solution (0·05 *M*), the cytochrome *c* was eluted with 0·2 saturated ammonium sulphate solution (eluate: $R_{280}^{550} = 0{\cdot}2–0{\cdot}3$). The solution containing about 0·05 per cent oxidized cytochrome *c* was saturated with ammonium sulphate at *p*H 5·0 and the resulting precipitate was removed (filtrate: $R_{280}^{550} = 0{\cdot}4–0{\cdot}7$). The filtrate was dialysed and cytochrome *c* further concentrated using *CS*-101 as before except that ammonium phosphate buffer solution (1·0 *M*, *p*H 7·0) was used for the elution.

The cytochrome *c* was purified by the method of Margoliash[4] with some modifications in which the resin, *XE*-64, treated with sodium hypochlorite and ammonium phosphate buffer solution (0·4 *M*, *p*H 7·0) was used. The cytochrome *c* eluted in the oxidized form at about four hold up volumes was collected and highly concentrated using a small column of *CS*-101 (eluate: $R_{280}^{550} \doteqdot 1{\cdot}15$). The solution, containing more than 10 per cent oxidized cytochrome *c*, was nearly saturated (about 0·85 saturation) with ammonium sulphate at *p*H 5·0 and the slight amount of resulting precipitate was removed (supernatant: $R_{280}^{550} \doteqdot 1{\cdot}2$).

Fig. 1. Crystalline yeast cytochrome *c* (rod form, × 1,500)

The cytochrome *c* contained in the supernatant was reduced with the minimum amount of ascorbic acid, adjusted to about *p*H 9·0 with 30 per cent ammonia (about 1/30 vol.), and then saturated by the addition of finely powdered ammonium sulphate in order to precipitate cytochrome *c*. When the resulting suspension was allowed to stand for 3–5 days, the precipitated cytochrome *c* changed into very small crystals. After centrifugation, the crude crystals were dissolved in the minimum amount of water (about 1/3 vol. of the crystals) (crude crystals : $R_{280}^{550} = 1{\cdot}25$). When finely powdered ammonium sulphate was added to the above solution until it became slightly turbid (about 0·8 saturation), small needle-like crystals appeared after one or two hours and then gradually changed into fairly large needles or rods as shown in Fig. 1 (first crystals : $R_{280}^{550} = 1{\cdot}28$). All the work was carried out at room temperature (10–15° C.). Recrystallization was carried out in the same way ; but the purity was not increased.

The crystallization of oxidized cytochrome *c* was performed in almost the same way, and the crystals with the same shape and purity as in the case of reduced cytochrome *c* were obtained. Crystallization was also carried out from a mixture of oxidized and reduced cytochrome *c*. However, it seems to be most convenient to crystallize the protein in its reduced form, since the solubility of the reduced protein in ammonium sulphate solution appears to be somewhat smaller than that of the oxidized form.

This method was quite reproducible and also applicable to the crystallization of the hæmoprotein from dry yeast with a few modifications. The yield of the crystals was about 50 mgm. from 1 kgm. of compressed yeast or 0·3 kgm. of dry yeast.

We wish to express our thanks to the Oriental Yeast Co., Ltd., for the supply of the source material, to the Japan Organo Co., Ltd., for the resin *XE*-64, and to the Nippon Kiko Co., Ltd., for *CS*-101.

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Takekazu Horio
Jinpei Yamashita
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Kazuo Okunuki

[1] Bodo, G., *Nature*, **176**, 829 (1955).
[2] See following communication.
[3] Paléus, S., and Neilands, J. B., *Acta Chem. Scand.*, **4**, 1024 (1950).
[4] Margoliash, E., *Biochem. J.*, **39**, 289 (1945).
[5] Minakami, S., *J. Biochem.*, **42**, 749 (1955).

Preparation of Crystalline Cytochrome *c* from Beef and Pig Heart

Crystalline cytochrome *c* was prepared from beef and pig heart by a method similar to that used for yeast[1] with a few modifications. Each of these two crystalline preparations was shown to be a homogeneous protein by electrophoretic, ultracentrifugal and chromatographic criteria[2] and to give the highest ratio of the extinction coefficient of the reduced form at 550 mμ to that of the oxidized form at 280 mμ ($R_{280}^{550} = 1{\cdot}29$ in beef, $R_{280}^{550} = 1{\cdot}28$ in pig).

Heart muscle, freed of fat and ligaments and washed with tap water, was minced and then extracted twice with 0·1 saturated ammonium sulphate solution. The residue was removed by filtration through a cloth using a press. In the case of beef heart, the residue was stored as a source of cytochromes *a* and *b*. In the case of pig heart, crystalline fumarase and lactic dehydrogenase were obtainable together with cytochrome *c* from the extract by separating the former two enzymes by a fractionation with ammonium sulphate at 0·8 saturation. In the case of both beef and pig, cytochrome *c* was concentrated by the slightly modified methods of Keilin and Hartree[3,4] from the filtrate from 0·8 saturated ammonium sulphate.

The concentrated cytochrome *c* was dissolved, dialysed against ammonium phosphate buffer solution (0·05 *M*, *p*H 7·0), and then further concentrated using 'Duolite' *CS*-101 as in the case of yeast[1] (concentrate : $R_{280}^{550} = 1{\cdot}1$–$1{\cdot}15$). The procedure followed exactly that used in the preparation of cytochrome *c* from yeast except that when the concentrated cytochrome *c* was chromatographed on *XE*-64 the buffer solution contained 0·25 *M* ammonium instead of 0·4 *M* (main peak : $R_{280}^{550} = 1{\cdot}2$). The cytochrome *c* thus obtained was more soluble in concentrated ammonium sulphate solution than that obtained from yeast, but the shapes of the crystals in various stages of the crystallization were almost identical.

This method was quite reproducible and the yields of the crystals from 1 kgm. of beef and pig heart were about 30 mgm. and 20 mgm., respectively.

The shapes of the cytochrome *c* crystals may be divided into four types : needle, rosette (Fig. 2), leaflet (Fig. 3) and slender rod-like forms. All these types have also been observed in crystals obtained from yeast, though the shape of the second type,

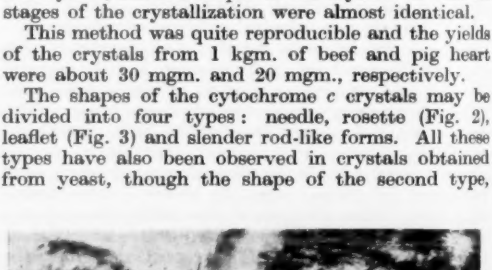

Fig. 2. Crystalline pig heart cytochrome *c* (rosette form, × 1,500)

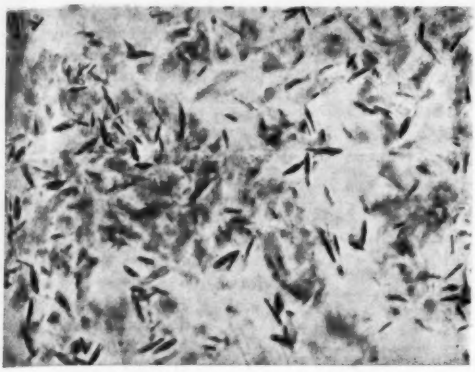

Fig. 3. Crystalline beef heart cytochrome *c* (leaflet form, × 900)

rosette, of yeast was somewhat different from the other. Needle and rosette crystals have usually appeared in the earlier period in the first crystallization and then changed into the leaf-like type which appeared also in the earlier period of the recrystallizations. These three types have often been changed into the slender rod-like form by careful recrystallizations and by allowing the suspension of crystals to stand for a very long time. It was supposed from these observations that the needle type might be a very small form of the rod type, while the rosette and leaflet types might comprise grouped forms of the needle. No other shapes of true crystalline cytochrome *c* have yet been obtained from the above three different sources. These cytochromes *c* have never been crystallized from a dilute solution, as in the method of Bodo[5] using king penguin muscle, although crystals of some other substance with clear edges slightly coloured (presumably by the adsorption of cytochrome *c*) have sometimes appeared, together with an amorphous precipitate of cytochrome *c*, under the conditions used by him.

Bunji Hagihara
Ichiro Morikawa
Ichiro Sekuzu
Takekazu Horio
Kazuo Okunuki

[1] See preceding communication.
[2] See following communication.
[3] Keilin, D., and Hartree, E. F., *Proc. Roy. Soc.*, B, **122**, 298 (1937)
[4] Keilin, D., and Hartree, E. F., *Biochem. J.*, **39**, 289 (1945).
[5] Bodo, G., *Nature*, **176**, 829 (1955).

Comparison of Properties of Crystalline Cytochrome *c* from Yeast, Beef Heart and Pig Heart

A few physical and biological properties of the crystalline cytochrome *c* obtained from baker's yeast, beef heart and pig heart by the methods previously described[1] are here recorded.

Absorption spectra of the three crystalline cytochrome *c*'s were found in the ultra-violet and visible regions to be practically identical with one another, and also with non-crystalline samples prepared from horse heart by the method of Keilin and Hartree[3] through the visible range. However, in the ultra-violet region at about 280 mμ, a difference was observed between the crystalline preparations and

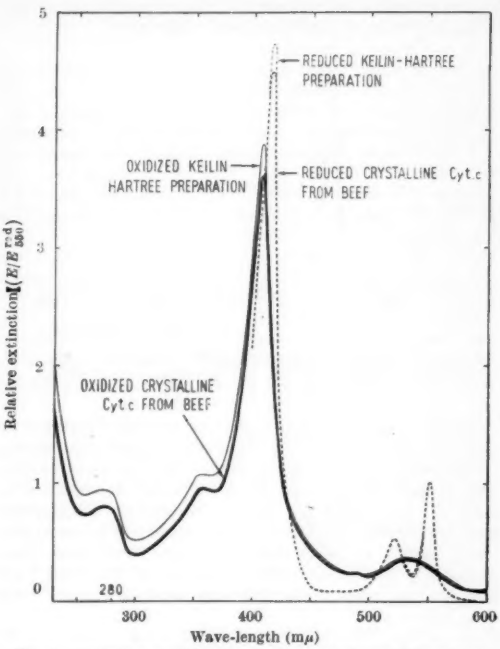

Fig. 4. Absorption spectra of crystalline cytochrome *c* from beef and Keilin–Hartree preparation from horse heart

the non-crystalline preparations (Fig. 4). This suggests the impurity of the latter.

Electrophoreses were performed at *p*H 9·0 using a sodium glycine–sodium chloride–hydrochloric acid buffer system of ionic strength 0·1. Each of the crystalline preparations in the oxidized form migrated in the electrical field as a homogeneous substance. Further analyses are now in progress under other conditions in order to confirm the homogeneity of these preparations and also to determine their isoelectric points.

Ultracentrifugal experiments were performed by Dr. K. Fukai, of the Institute for Microbial Diseases, University of Osaka, using a 'Spinco' Model-*E*; the runs were carried out in sodium chloride solution of *p*H 6·0 and ionic strength of 0·2 at a protein concentration of 0·5–0·2 per cent. All the above three crystalline preparations showed only one peak in the centrifugal field at 59,780 r.p.m. (Fig. 5).

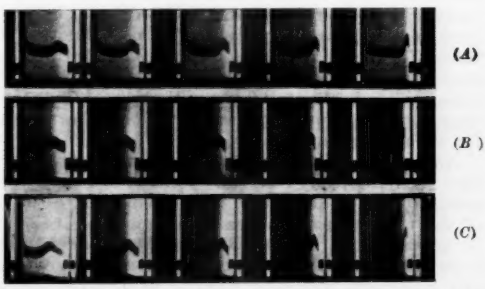

Fig. 5. Ultra-centrifugal diagram of crystalline cytochrome *c* from (*A*) yeast, (*B*) beef heart, and (*C*) pig heart. Solvent, 0·2*M* sodium chloride; protein concentrations, (*A*) and (*B*) 0·2 per cent, (*C*) 0·45 per cent; 59,780 r.p.m. in a 'Spinco' Analytical *A* rotor with 12-cm. cell; interval, (*A*) 16 min., (*B*) and (*C*) 34 min.

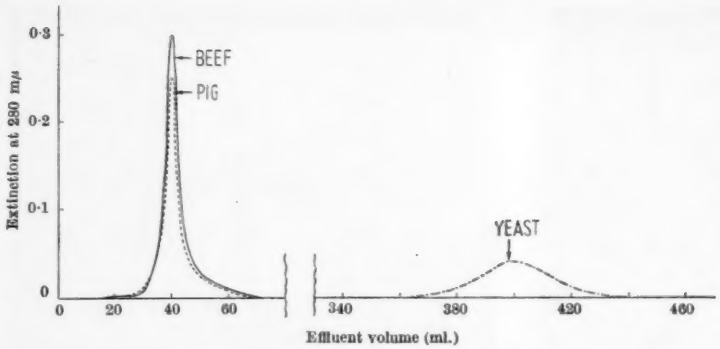

Fig. 6. Chromatograms of crystalline cytochrome *c* from yeast, beef heart and pig heart. Column, 'Amberlite' *XE*-64, 150–300 mesh, 1 cm. × 26 cm.; buffer, ammonium phosphate *p*H 7·0, 0·3 *M* ammonium; rate of flow, 10 ml./hr.

Analytical chromatography of the oxidized forms was carried out on a column of ion exchange resin, 'Amberlite' *XE*-64, according to the method of Hirs, Moore and Stein[3], except that resin treated with sodium hypochlorite, and ammonium phosphate buffer solution of *p*H 7·0 containing 0·3 *M* ammonium were used. In each case only one clear peak was obtained, though the elution volumes for the yeast preparation were very different from the other two (Fig. 6).

Biological activities of the three cytochromes *c* were tested in the succinic oxidase system and the cytochrome oxidase system prepared from beef heart muscle by the method of Keilin and Hartree[4]. The efficiencies of the three preparations in these systems were almost the same, based on the extinction at 550 mμ in the reduced form.

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DETERMINATION OF INTERMEDIARY METABOLITES BY ENZYMIC FLUORIMETRY

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WORK now in progress on the metabolism of the peripheral nervous system requires more sensitive methods than are generally available for the assay of various intermediary metabolites. In recent years increasingly widespread use has been made of the difference of ultra-violet absorption properties of oxidized and reduced pyridine nucleotides for the determination of intermediary metabolites. These compounds also differ in their fluorescence properties. Reduced diphosphopyridine nucleotide and reduced triphosphopyridine nucleotide are fluorescent, whereas the corresponding oxidized forms are not. This difference in the fluorescence properties of the reduced and oxidized forms has been used in the determinations to be described as the basis of a direct method for the estimation of intermediary metabolites at levels as low as 2×10^{-10} mole. This is about 100 times the sensitivity of the ultra-violet absorptiometric methods hitherto used for such determinations.

Any of the large number of compounds capable of being enzymatically coupled, by one or more enzymes, either to the oxidation or to the reduction of either of the two nucleotides should be amenable to assay by this method. So far, this fluorimetric method has been found suitable for the determination of a number of compounds, including pyruvic acid, phosphoenolpyruvic acid, adenosine diphosphate, adenosine triphosphate and glucose-6-phosphate. The problem of non-absolute enzyme specificity, such as keto-acids other than pyruvate reacting with lactic dehydrogenase[1] and nucleotides other than adenine nucleotides reacting with 'adenine nucleotide enzymes', are, of course, similar to those encountered in the spectrophotometric assay methods.

The measurements reported here were made with a Hilger 'Spekker' absorptiometer modified in this laboratory to serve as a fluorimeter using an *E.M.I.* 6097*B* photomultiplier as the light detector.

Pyruvic acid. This compound was estimated, as in the spectrophotometric method of Ochoa *et al.*[2], in the presence of lactic dehydrogenase and excess reduced diphosphopyridine nucleotide. One molecule of the latter is oxidized for each molecule of pyruvate present, according to the following reaction:

pyruvate + reduced diphosphopyridine nucleotide → lactate + diphosphopyridine nucleotide (1)

The disappearance of reduced diphosphopyridine nucleotide, determined by decrease in fluorescence, is proportional to the pyruvate present. It can be seen from Fig. 1 that pyruvate can be estimated in amounts of $2{\cdot}5 \times 10^{-10}$ mole in a volume of 1 ml.

Although diphosphopyridine nucleotide and triphosphopyridine nucleotide do not ordinarily fluoresce, they can be made to do so by condensation with ketones in an alkaline medium[3]. These condensation products are many times more fluorescent than the reduced pyridine nucleotides, the fluorescence of which is not increased by this treatment. The

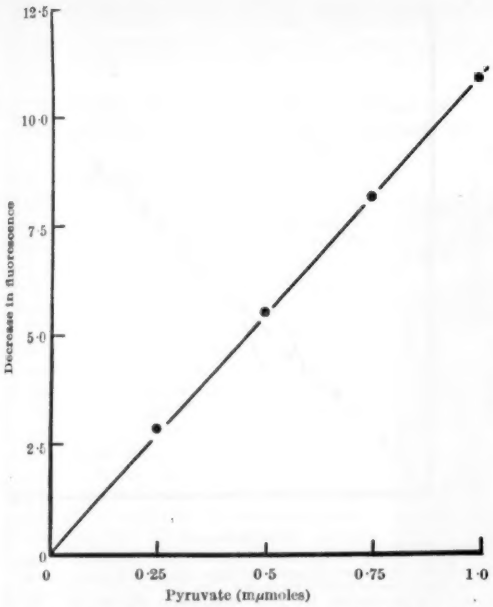

Fig. 1. Assay of pyruvate: Reaction mixture (1 ml.) contained 10 μmol. triethanolamine, *p*H 7·7, 0·5 μmol. ethylenediaminetetra-acetate, *p*H 7·4, 1·6 mμmol. reduced diphosphopyridine nucleotide and indicated amounts of pyruvate. Reaction started by addition of 0·01 ml. (40 Bücher units) of lactic dehydrogenase. Readings taken every minute at room temperature until stable value is obtained. Blank corrections (no added pyruvate) have been applied

combined use of lactic dehydrogenase, excess pyruvate and this ketone procedure was previously employed for the estimation of reduced diphosphopyridine nucleotide[4]. The procedure has now been used for estimating pyruvate by using an excess of reduced diphosphopyridine nucleotide. Following the completion of reaction (1) the diphosphopyridine nucleotide formed is measured by the fluorescence of its ketone condensation product. With this procedure, pyruvic acid was estimated in amounts as small as $2{\cdot}5 \times 10^{-11}$ mole (Fig. 2).

The ten-fold greater sensitivity of the ketone procedure suggests it as the method of choice for the estimation of pyruvate and other compounds when such extra sensitivity is desired. On the other hand, the direct use of reduced diphosphopyridine nucleotide fluorescence for these estimations has certain advantages. One is the greater simplicity of the procedure. Another is that the progress of the reaction can be followed continuously, with the result that the termination of the reaction can be ascertained with greater ease and accuracy. Finally, a second compound can be estimated on a given aliquot (see estimation of adenosine diphosphate and phosphoenolpyruvate).

Adenosine diphosphate and phosphoenolpyruvate. By a simple extension of the fluorimetric method for the assay of pyruvate, either adenosine diphosphate or phosphoenolpyruvate may be estimated at similar low levels. As in the spectrophotometric procedure of Kornberg and Pricer[5], the addition of Mg^{++}, K^+ and pyruvic phosphokinase to the reaction mixture used for the determination of pyruvate permits the estimation of either of these compounds according to the reaction:

adenosine diphosphate + phosphoenolpyruvate → adenosine triphosphate + pyruvate (2)

the pyruvic acid formed reacting according to equation (1). In the presence of excess phosphoenolpyruvate, the decrease in fluorescence gives a measure of the adenosine diphosphate present. As shown in Fig. 3, the sensitivity of the method is such as to allow for the estimation of less than 2×10^{-10} mole of adenosine diphosphate in a 1·0 ml. volume. If pyruvate is present, it can be estimated separately as above and the adenosine diphosphate content obtained by difference. Alternatively, pyruvate and adenosine diphosphate can be determined on a single aliquot by first estimating the pyruvate in the presence of lactic dehydrogenase and then adding pyruvic phosphokinase, Mg^{++} and K^+ for the estimation of adenosine diphosphate. It was found necessary to withhold the addition of Mg^{++} until the pyruvate estimation was completed, since even highly purified samples of lactic dehydrogenase contain small traces of pyruvic phosphokinase and therefore some adenosine diphosphate might be estimated along with the pyruvate.

The same principle when applied to the determination of phosphoenolpyruvate by adding adenosine diphosphate in excess gave a similar sensitivity.

Glucose-6-phosphate and adenosine triphosphate. Glucose-6-phosphate is estimated, as in the spectrophotometric method of Ochoa *et al.*[6], in the presence of glucose-6-phosphate dehydrogenase (*Zwischenferment*) and excess triphosphopyridine nucleotide. One molecule of triphosphopyridine nucleotide is reduced for each molecule of glucose-6-phosphate present according to the reaction:

glucose-6-phosphate + triphosphopyridine nucleotide → 6-phosphogluconic acid + reduced triphosphopyridine nucleotide (3)

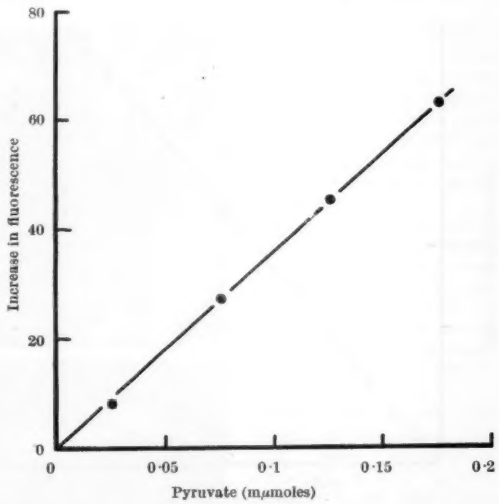

Fig. 2. Assay of pyruvate, ketone method. Reaction mixture (0·5 ml.), containing 5 μmol. triethonalamine, *p*H 7·4, 0·2 μmol. ethylenediaminetetra-acetate, *p*H 7·4, 0·25 mμmol. reduced diphosphopyridine nucleotide, indicated amounts of pyruvate and 40 Bücher units of lactic dehydrogenase, was incubated at 39° for 15 min., followed by addition, with mixing, of 0·2 ml. of 0·0002 *M* manganous chloride in methyl ethyl ketone, 0·2 ml. of 4·2 *N* sodium hydroxide, and, after waiting 5 min., 0·95 ml. of 1·0 *N* hydrochloric acid. Solution boiled 5 min., cooled and readings taken. Blank corrections (no added pyruvate) have been applied

The formation of reduced triphosphopyridine nucleotide, determined by increase in fluorescence, is proportional to the glucose-6-phosphate present.

As in the spectrophotometric procedure of Kornberg[7], the addition of hexokinase and glucose to the reaction mixture used for the estimation of glucose-6-phosphate permits the estimation of adenosine triphosphate according to the reaction:

adenosine triphosphate + glucose → adenosine diphosphate + glucose-6-phosphate (4)

the glucose-6-phosphate formed reacting according to equation (3). This is illustrated in Fig. 4; less than 2×10^{-10} mole of adenosine triphosphate was estimated in a 1·0 ml. volume. If glucose-6-phosphate is present, it can be estimated separately as above in the absence of reaction (4) and the adenosine triphosphate content obtained by difference.

Alternatively, glucose-6-phosphate can be estimated, according to the procedure of Slater[8], in the presence of excess reduced diphosphopyridine nucleotide and adenosine triphosphate using an enzyme system from rabbit muscle. In this procedure, glucose-6-phosphate is measured by the oxidation of reduced diphosphopyridine nucleotide. By measuring the decrease in fluorescence as the reduced diphosphopyridine nucleotide was oxidized, 4×10^{-10} mole of glucose-6-phosphate was readily estimated in a volume of 7·3 ml.

A limitation in the estimation of metabolites at the level of sensitivity potentially available by fluorimetry is the purity of the enzymes used. Among the many substances which should be readily estimated by this fluorescence method are isocitrate, α-ketoglutarate and the triose phosphates, since the respective enzymes catalysing reactions between these intermediates and the pyridine nucleotides have been crystallized.

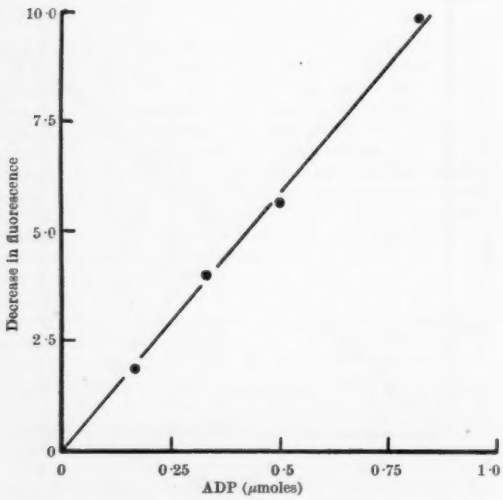

Fig. 3. Assay of adenosine diphosphate. Reaction mixture (1·0 ml.) contained 10 μmol. triethanolamine, *p*H 7·7, 0·5 μmol. ethylenediaminetetra-acetate, *p*H 7·4, 1·6 mμmol. reduced diphosphopyridine nucleotide, 20 μmol. magnesium sulphate, 80 μmol. potassium chloride, 1·6 mμmol. phosphoenolpyruvate and indicated amounts of adenosine diphosphate. Reaction started by addition of 0·01 ml. (40 Bücher units) of lactic dehydrogenase and 0·03 ml. (40 Bücher units) of pyruvic phosphokinase. Readings taken every minute at room temperature until stable value was obtained. Blank corrections (no added adenosine diphosphate) have been applied

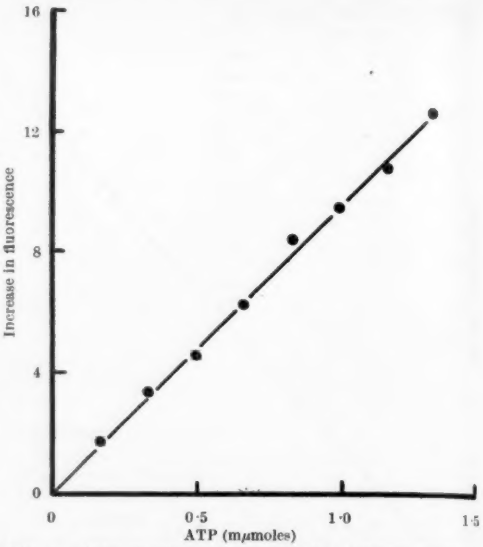

Fig. 4. Assay of adenosine triphosphate. Reaction mixture (1·0 ml.) contained 35 μmol. triethanolamine, *p*H 8·2, 0·2 μmol. ethylenediaminetetra-acetate, *p*H 7·4, 2·2 mμmol. triphosphopyridine nucleotide, 5·0 μmol. magnesium chloride, 100 μmol. glucose and indicated amounts of adenosine triphosphate. Reaction started by addition of 0·1 ml. (0·075 Kornberg units) of glucose-6-phosphate dehydrogenase containing hexokinase. Blank corrections (no added adenosine triphosphate) have been applied

Just as the spectrophotometric assay methods have been suitable for the estimations both of intermediary metabolites and of the activities of the related enzymes catalysing the reactions between these metabolites, so the fluorimetric methods described here for the estimation of intermediary metabolites can be used, with slight alterations, for the very sensitive estimation of enzyme activities. In fact, the activities of the enzymes used in this work were usually tested fluorimetrically. Theorell *et al.*[9] have found the sensitivity of fluorescence measurements to be very useful in their study of the reaction mechanisms of pyridine nucleotide enzyme systems.

Note added in proof: Lowry *et al.*[10] have used a similar procedure for the estimation of tissue-levels of glutamic dehydrogenase.

I am grateful to Prof. Th. Bücher for a gift of crystalline lactic dehydrogenase and pyruvic phosphokinase. It is a pleasure to thank Prof. Th. Bücher, Dr. W. Feldberg, Prof. E. C. Slater and Dr. T. S. Work for stimulating discussions. This work was carried out during the tenure of the Doris Duke Foundation Fellowship of the National Paraplegia Foundation, U.S.A.

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LETTERS TO THE EDITORS

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Electron Microscope Observations of Periodicities in the Surface Structure of Tobacco Mosaic Virus

X-RAY diffraction data and chemical evidence suggest that the protein content of tobacco mosaic virus rods is built up of small sub-units[1]. A model has been proposed[2] in the form of a helix of pitch of 23 A. and repeat distance of 69 A.

By electron microscopy using the carbon replica technique[3] we have obtained direct evidence for a structure repeating at 46 A. along the axis of the virus. A longitudinal structure of ridges and furrows has also been resolved which may indicate a polygonal cross-section for the virus rod. This is difficult to reconcile with recent deductions[4] from X-ray diffraction experiments that the virus rod has a hollow centre of radius 20 A. and a concentration of nucleic acid at a radius of 40 A.

A 'type' strain of tobacco mosaic virus was grown in tobacco plants and the virus isolated by the usual ammonium sulphate precipitation procedures. The suspension was dried on carefully cleaned glass surfaces and carbon was evaporated directly on to the preparation at an angle of about 30° from the horizontal. After stripping the carbon from the slide, the replica was placed in 2 *N* potassium hydroxide at 60° C. to remove any virus rods remaining attached to the carbon. Finally, the replica was washed using the methods described by Bradley[3]. Direct suspensions shadowed with metal[5,6] and pre-shadowed replicas[7] were not found to be successful for studies at high resolution. Very thin evaporated metal films, normally used in electron microscopy to enhance contrast, are then found to consist of very small particles which confuse rather than reveal much of the fine detail in the specimen. The type of structure produced by shadowing is in agreement with that found by Sennett and Scott[8].

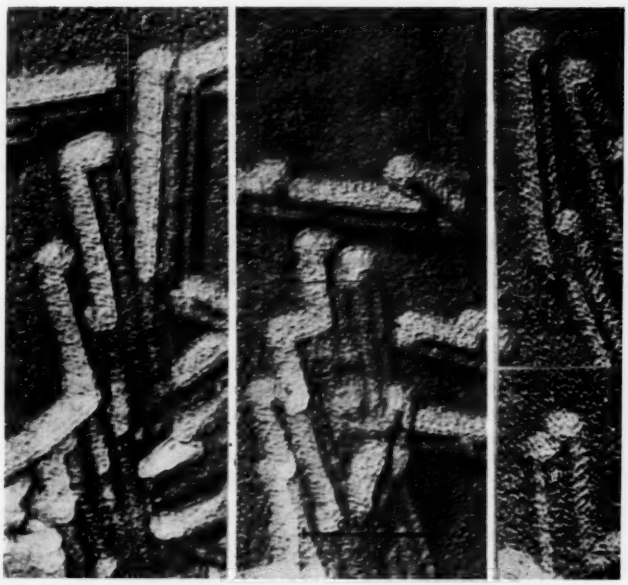

Fig. 2. Carbon replica of tobacco mosaic virus rods lying parallel to the direction of evaporation, showing 'herring-bone' structure and also longitudinal structure. (Original magnification × 40,000; reproduced at × 200,000.) Scale = 0·1μ

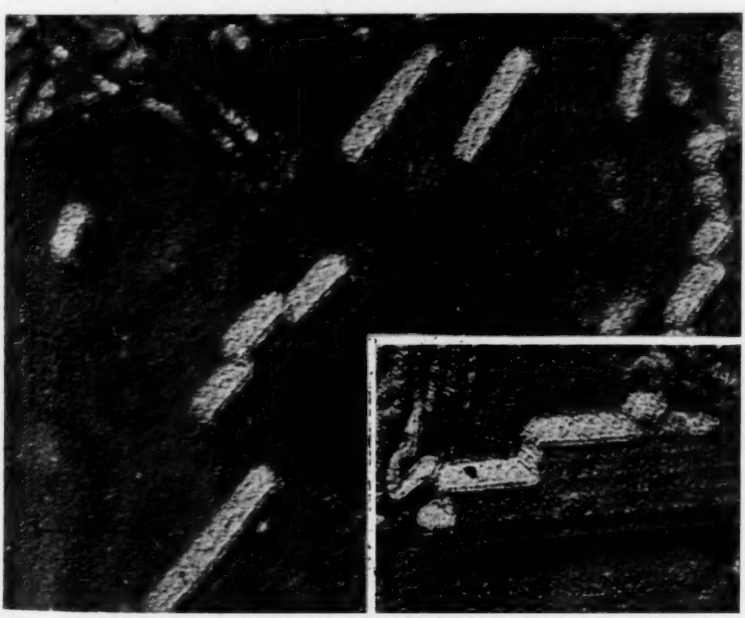

Fig. 1. Single-stage carbon replica of tobacco mosaic virus rods lying across the direction of incidence of the evaporated carbon, showing longitudinal structure along the rods. (Original magnification, × 40,000; reproduced at × 200,000.) Scale = 0·1μ

The replicas were examined in the electron microscope at instrumental magnifications of × 40,000 and × 80,000. In Fig. 1, where numerous rods lie across the direction of incidence of the evaporated carbon, a longitudinal structure is visible running the full length of the virus rod. The same longitudinal structure is also resolved in Fig. 2, in rods lying parallel to the direction of incidence of the carbon. Fig. 2 also shows a 'herring-bone' structure in some of these rods. Measurements made from prints enlarged to × 400,000 gave a mean value of 46 A. for

the axial repeat-distance of this structure, which is almost exactly double that of the pitch of the helix deduced from the X-ray data. In the few rods which show evidence of helical structure, the angle of advance was found to be between 80° and 85°, as compared with the value of 82·5° required by the model proposed by Franklin[1]. The width of the rods, measured in regions of close packing, is found to be 150 ± 5 A.

One of the most striking features is the angular appearance of the virus rod in cross-section, suggesting a hexagonal form with a groove at the corners. A series of electron micrographs through the focus has been taken to ensure that the pronounced ridges are not due to electron optical fringe effects. Mixed preparations of tobacco mosaic virus and turnip yellow mosaic virus have been examined under the same conditions. These observations showed that the structures described were confined to the tobacco mosaic virus.

This work has been carried out with the assistance of a grant from the Agricultural Research Council, to which we are indebted. We also wish to thank Dr. R. Markham for supplying some of the tobacco mosaic virus and for several valuable discussions.

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Fine Structure of Tobacco Mosaic Virus

Although tobacco mosaic was one of the first viruses to be examined in the electron microscope, electron microscopy has failed to reveal any fine structure, even though it has been repeatedly looked for[1,2], especially since the introduction[3] of metal shadow casting in 1945.

The present findings result from a study directed at increasing the visibility of macromolecules in the electron microscope, and in particular from evaporating heavy metal at angles (with respect to the substrate) close to 0°.

A sample of the *U*1 strain[4] of tobacco mosaic virus, buffered to *p*H 6·8 in cacodylic acid, was diluted with distilled water to a concentration of 0·005 mgm./ml. and then sprayed on to the collodion-covered convex face of a plano-convex lens of 250 mm. radius of curvature. Thorium was evaporated at a pressure 10^{-4} mm. of mercury from a tungsten filament, the height of the lens being adjusted so as to give grazing incidence of the metal beam near the pole of the lens.

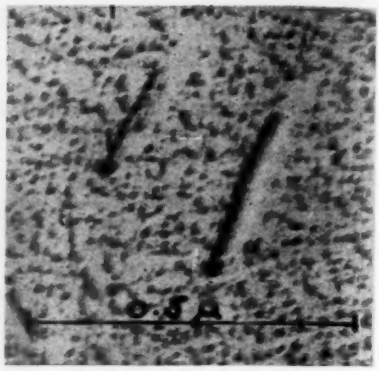

Fig. 1. Electron micrograph of tobacco mosaic virus (*U*1 strain) air-dried on collodion substrate and shadow-cast with thorium at low angle. The direction of shadowing is from lower left. (× 100,000)

The collodion was then stripped from the glass and mounted on 200-mesh copper screens. This technique offered a range of incidence angles in the neighbourhood of 0°, the exact angle depending on the original position on the glass surface.

At angles of incidence near 0°, tobacco mosaic rods which lay perpendicular to the direction of the incoming beam appeared normal, with thorium piling up on the incident side. Rods which lay parallel to the incoming beam, however, showed a periodic density variation along the long axis, in addition to the metal cap on the end which would be expected (Fig. 1). The visibility of the striations decreased as the orientation of the rod varied from parallel to perpendicular. The visibility of the striations was also very sensitive to shadowing angle, the striations disappearing completely for angles greater than approximately 5°.

The period of the density fluctuations along the rod axis, as measured from a number of rods, averaged 136 A. As seen in Fig. 1, the individual striations are not perpendicular to the long axis of the rod, and the net effect is that of a right-handed helix.

Franklin and Klug[4] have recently published X-ray evidence for the existence of a helical groove or helical array of protuberances on the surface of the tobacco mosaic virus rod. The X-ray data can be interpreted as showing a discontinuity 30 A. deep, with the pitch of the underlying protein. While no agreement exists on the value of the pitch, the X-ray value for depth of groove is of the same order as that deduced in this work.

From the variation in contrast as a function of shadowing angle, it can be deduced that the slope of the discontinuity responsible for the deposition of metal must be no more than a few degrees, and the height of the discontinuity is of the order 15–30 A. A simple calculation based on the shadowing angle and the amount of thorium evaporated shows that migration and crystallization of thorium atoms on the rod surface will not account for the observed effect.

Similar results for the *U*2 strain of virus have been obtained, with some differences which will be reported on more fully elsewhere.

I wish to thank Dr. A. Siegel for furnishing the tobacco mosaic virus used in this investigation, which

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Differences in the Chemical Composition of the Phage Nucleic Acids

IT has been known for some time that the nucleic acids of the coli-dysentery phages, T_2, T_4 and T_6, contain hydroxymethylcytosine and that the composition of their purine and pyrimidine bases is essentially identical[1]. More recently it was found in this laboratory that a hexose is present in T_4 phage[2]. This sugar was identified as glucose and was shown to be a constituent of the viral nucleic acid[3]. It was afterwards demonstrated that T_2 and T_6 nucleic acids also contain glucose and that enzymatic hydrolysates of T_2 and T_4 nucleic acids contain small quantities of the glucoside of hydroxymethylcytidylic acid[4,5]. In the present communication it will be shown that the nucleic acids of T_2, T_4 and T_6 phages differ in their content of glucose and that this hexose is attached to the acid-resistant part of nucleic acid, the apurinic acid.

The wild type (r^+) strains of T_2, T_4 and T_6 viruses were used in this study. They were grown on *E. coli B* in synthetic medium and purified by procedures already described[6]. In order to obtain the viral nucleic acids, aqueous suspensions of the phages were repeatedly frozen and thawed and then deproteinized with chloroform and octyl alcohol in presence of 1 *M* sodium chloride. The nucleic acids were precipitated with ethanol, then dialysed and dried from the frozen state.

The materials thus obtained formed viscous solutions and showed adsorption spectra characteristic of nucleic acid. Their atomic extinction coefficients ($\varepsilon(P)$ at 260 mμ) varied between 7020 and 7280. From Table 1 it can be seen that the nucleic acids derived from T_2, T_4 and T_6 phages differed slightly yet significantly in their nitrogen and phosphorus content. Colorimetric and chromatographic analyses revealed that deoxypentose as well as glucose were components of each. The purine-bound deoxypentose was determined quantitatively with diphenylamine using deoxyribose as a standard. Glucose was determined by means of the anthrone reaction.

Table 1. CHEMICAL COMPOSITION OF THE NUCLEIC ACIDS AND THE APURINIC ACIDS OF T_2, T_4, T_6 VIRUSES

	N (per cent)	P (per cent)	Glucose (per cent)	[Glucose]/[P]
T_2 nucleic acid	14·1	8·4	6·7	0·14
T_4 " "	13·8	8·0	8·4	0·18
T_6 " "	12·8	7·4	12·0	0·28
T_2 apurinic acid	5·9	9·8	7·9	0·14
T_4 " "	5·7	9·7	9·9	0·18
T_6 " "	5·2	9·0	14·0	0·27

Since deoxyribose produces a colour with this reagent, absorption was measured at 620 and at 500 mμ and the content of glucose calculated according to the procedure of Knudson, Meloche and Juday[7]. The amount of deoxyribose in the three nucleic acids varied but slightly (18·8–19·8 per cent), whereas differences in glucose content were considerable. The T_2, T_4 and T_6 nucleic acids were found to contain 6·7, 8·4 and 12·0 per cent of glucose respectively. Thus, for each mole of phosphorus there was present 0·14 moles of glucose in the T_2 nucleic acid, 0·18 moles in the T_4 nucleic acid and 0·28 moles in the T_6 nucleic acid. Since each nucleic acid contained approximately 0·17 mole of hydroxymethylcytosine per mole of phosphorus[1] it is evident that the amount of glucose in the nucleic acids derived from T_4 and T_6 exceeds that of the pyrimidine. In the case of T_2 nucleic acid this amount is less.

In order to gain some information concerning the nature of the glucose linkage in the viral nucleic acids, the latter were hydrolysed with dilute sulphuric acid at *p*H 1·6 and at 37° C. After dialysis to remove purine bases, the apurinic acids were recovered by lyophilizing the residues[1].

The three viral apurinic acids showed typical absorption spectra when measured at *p*H 6·8, with maxima at 267–68 mμ and minima at 235–38 mμ; their atomic extinction coefficients ($\varepsilon(P)$ at 260 mμ) varied from 4050 to 4280. Chemical analyses revealed that each contained considerably less nitrogen and more phosphorus than the intact nucleic acids from which they were derived. The low molar ratio of N/P (1·3) indicated that on hydrolysis the bulk of the purines was split off. The content of deoxyribose and glucose was increased to 23·0–23·8 and 7·9–14·0 per cent respectively. The molar ratios of glucose to phosphorus were similar to those found in the viral nucleic acids themselves. This fact indicates that glucose is attached mainly to the acid-resistant part of the nucleic acid molecule.

From the data which have been presented, it is apparent that the nucleic acids of T_2, T_4 and T_6 phage differ from the usual nucleic acids in that they contain not only hydroxymethylcytosine but glucose as well. The amount of this saccharide in the three viral nucleic acids appears to be different. The evidence at hand indicates that glucose is bound to the apurinic part of the molecule, probably in the form of a glucoside of hydroxymethylcytidylic acid. Where more glucose than hydroxymethylcytosine is present, it is apparent that part of the sugar must be linked to the pyrimidine in a different manner, perhaps as a disaccharide. The confirmation of this must await further experimentation.

Since this communication was submitted for publication, a report describing variations in the glucose–deoxyribose ratio in r^+ and r variants of T-even phages has appeared[8].

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Physical Basis of Insect Repellency

The physical basis of insect repellency being unknown, the search for new repellents has had to be conducted on an essentially hit-or-miss basis. With the accumulation of evidence that the odours of substances may be correlated with the low-frequency, fundamental vibrations of their molecules[1], it seemed worth while to examine the absorption of some typical insect repellents in the far infra-red part of the spectrum.

The following commercial insect-repellent substances were available: dimethyl phthalate, indalone, 2-ethyl hexanediol-1,3, benzyl benzoate, *n*-propyl-N,N-diethyl succinamate and butoxy propylene glycol. In order to increase the statistical weight of the results, additional substances were chosen on the basis of ready availability from the extensive list of repellent chemicals published by Morton, Travis and Linduska[2].

These workers tested 6,241 chemicals as mosquito repellents. The tests were made by covering the forearms of test subjects from wrist to elbow with the chemical or with a treated cloth, and then exposing them in cages containing some thousands of unfed mosquitoes (*A. aegypti*). The substances were graded on the basis of the duration of protection they afforded, the most effective substances being placed in group 4 and the least effective in group 1. This method of screening could only have been approximate, and individual substances may now and then have been wrongly classified (benzyl benzoate, for example, was placed in group 1 and has since found application as a repellent); yet a random selection of compounds from group 4 may be expected to consist mainly if not entirely of repellents, and a similar selection from group 1 will be mainly non-repellent.

Fourteen substances showing grade 4 repellency were collected from available chemical stocks to give a test set of twenty repellents altogether. A control group of twenty non-repellent (group 1) substances was also assembled from available chemical stocks. Infra-red absorption curves were recorded in the region from 700 to 400 cm.$^{-1}$ using a Perkin-Elmer Model 21 infra-red spectrophotometer equipped with a potassium bromide prism and a linear wave-number cam. Liquids were examined as received. Solids were usually examined as mulls in 'Nujol' (which is transparent in this region) or, in a few cases, as compressed films with potassium bromide.

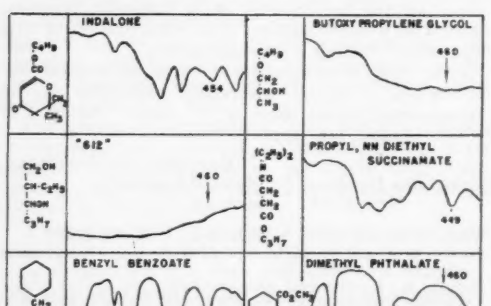

Fig. 1

The absorption curves of the six commercial repellents are shown in Fig. 1. The results exhibit a striking correlation in the part of the spectrum near 460 cm.$^{-1}$. Of the whole group of twenty repellent substances, thirteen have peaks between 449 and 471 cm.$^{-1}$, three of the remainder show strong continuous absorption in this region, and three have nearby broad bands which overlap this region. Of the non-repellent substances, only one has a peak between 449 and 471 cm.$^{-1}$ and the rest with few exceptions show very little absorption in the neighbourhood of 460 cm.$^{-1}$.

The only marked exception in the repellent group is dimethyl phthalate, the repellent properties of which are well known; it has no absorption peak near 460 cm.$^{-1}$. This substance is, however, one of the few members of the repellent group the structure of which is sufficiently symmetrical for certain vibrational modes to be inactive in the infra-red. It may be significant that the Raman spectrum of this substance[3] has a line at 230 cm.$^{-1}$.

Thus the conclusion seems inescapable that the physical basis of mosquito repellency is a molecular vibrational mode capable of giving rise to infra-red absorption or Raman scattering near 460 cm.$^{-1}$ (or 21·7μ). Whether other species of insect are repelled by molecules exhibiting this or some other characteristic frequency is not yet known. The practical value of these results in screening new substances for mosquito repellency will be evident at once. Their bearing on the general problems of olfaction is to lend support to the hypothesis that the low-frequency vibrations of molecules provide the physical basis of their odours. A discussion of the mechanism whereby such vibrations may be able to trigger nerve discharges will be published elsewhere.

I thank the Van Ameringen Co., Firmenich, Inc., and Dr. Hubert Martin for the gift of samples.

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Effect of Fungicides on Fungus Enzymes

Evidence has already been obtained to show that an important mechanism of the toxic action of fungicides is the inhibition of fungus enzymes. Copper and mercury are known to inhibit different systems, including those concerned with carbohydrate metabolism[1]. Rich and Horsfall[2] have investigated the action of phenols and quinones upon polyphenol oxidase, while Owens[3] has examined the effect of organo-sulphur compounds, phenols, quinones and metal compounds upon amylases, polyphenol oxidase and catalase. Attention has been given to the mode of action of different types of derivatives of thiocarbamic acid. Weed, McCallan and Miller[4] found that ferbam (ferric dimethyldithiocarbamate) inhibited urease, whereas nabam (disodium ethylene bisdithiocarbamate) had little effect. Sisler and Cox[5] attribute the toxicity of thiram (bis(dimethylthiocarbamoyl) disulphide) largely to the inhibition of the

enzyme triosephosphate dehydrogenase. The activity of 8-hydroxyquinoline has been ascribed[6] to chelation with metal ions essential for enzyme action. Owens[7] has shown that captan (N-trichloromethylthio-*cyclo*hex-4-ene-1,2-dicarboxyimide) prevents the assimilation of inorganic phosphate, and Hochstein, Cox and Sisler[8] have reported that this compound affects cellular metabolism by blocking key decarboxylation reactions.

We have examined the effects of four fungicides upon enzymes of *Sclerotinia laxa* Aderh. and Ruhl., the fungus responsible for the blossom wilt disease of fruit trees. The fungicides used were captan, copper (as sulphate), lime sulphur and *o*-phenyl phenol. Cultures of the fungus were grown on dextrose–peptone–phosphate liquid medium, in which the fungicides were incorporated in amounts found by trial to produce approximately 50 per cent inhibition of growth after incubation at 25° C. for seven days. The fungus felts were washed with water and frozen at −17° C. for 12 hr. or more before grinding them with three times their weight of cold 0·1 *M* phosphate buffer, *p*H 7·5, in a mortar and then in a Ten Broeck glass macerator at 0° C. The homogenate was centrifuged at 2,000 *g* for 10 min. at 4° C. The cell-free extracts were dialysed for 12 hr. against the buffer in which they were prepared, so as to reduce the endogenous rates of the enzymes examined. The following enzymes were determined in 'phosphate' extracts: catalase, peroxidase, cytochrome *c* oxidase and reductase, diphosphopyridine nucleotide oxidase (diaphorase), succinic, *iso*citric and glutamic dehydrogenases, fumarase and polyphenol oxidase. Tris(hydroxymethyl)aminomethane (0·1 *M*, *p*H 7·5) extracts of the felts were used for the determination of hexokinase, aldolase and alkaline phosphatase.

Protein was determined in the extracts by the method of Folin, and enzyme activities were expressed in units per milligram protein (specific activities). The results are shown in Table 1.

Lime sulphur markedly depressed the iron enzymes, but showed little further effect beyond a stimulation of aldolase. Copper treatment appreciably reduced aldolase and fumarase and stimulated diphosphopyridine nucleotide oxidase and hexokinase. Treatment with captan enhanced diphosphopyridine nucleotide oxidase and depleted glutamic dehydrogenase. *o*-Phenyl phenol depressed the flavoprotein diphosphopyridine nucleotide oxidase system.

It is interesting to note that while copper depressed cytochrome *c* oxidase, it exerted a compensating effect by stimulating the alternative diphosphopyridine nucleotide oxidase system for electron transport. The reverse, however, is seen with *o*-phenyl phenol, where a reduction in the activity of diphosphopyridine nucleotide oxidase was accompanied by an increase in that of cytochrome *c* oxidase.

Table 1. Effect of Fungicides on Enzymes of *S. laxa*

Enzyme	Captan	Copper	Lime sulphur	*o*-Phenyl phenol
Catalase	+	−	−−	−
Peroxidase	−	0	−−	−
Cytochrome *c* oxidase	0	−−	−−	++
Cytochrome *c* reductase	+	−	−−	+
Diphosphopyridine nucleotide oxidase	++	++	+	−−
Succinic dehydrogenase	0	0	−	−
*iso*Citric dehydrogenase	−	−	−	0
Glutamic dehydrogenase	−−	−	+	0
Hexokinase	0	++	−	0
Aldolase	−	−−	++	0
Alkaline phosphatase	0	0	−	0
Fumarase	−	−−	−	0
Polyphenol oxidase	−	−	0	+

−, Some depression; −−, marked depression; 0, no effect; +, some stimulation; ++, marked stimulation.

Further studies may lead to a more rational selection of toxicants for the control of pathogenic fungi. The work is being extended to include other fungi and fungicides.

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Antibacterial Substances in Seeds

While investigating the physiology of germination, it was noted that micro-organisms occurring on the seeds of certain species proliferated rapidly during germination, whereas the seeds of some other species, germinating under the same conditions, remained sterile. It seemed obvious that certain seeds must contain and release—during germination—compounds that are able to inhibit the growth of certain micro-organisms. In order to examine this hypothesis, the antibacterial effect of seeds of several species and varieties of plants has been investigated.

To carry out these examinations the agar-diffusion method[1] seemed to be the most adequate. In a Petri dish fresh bacterium suspension was run on to a solid, 5 mm. thick bouillon agar-plate, containing 2 per cent agar at *p*H 7. After removing the excess and having dried the surface, the experimental seeds were sunk into the culture medium. As the micro-organisms to be tested have been selected from the rapidly proliferating species, a previous disinfection of the seeds that might dissolve the antibacterial compounds was unnecessary. The time of incubation was 20 hr. at 30° C. The clear zones occurring during this time indicated the presence of antibacterial compounds and their size gave information about the intensity of the effect.

Whole seeds were examined, as the natural process of germination was considered to be of chief importance. The only exceptions were the species of *Fraxinus*, the seeds of which, cut transversely, were placed on the agar plate in order to see whether the compound within the seeds inhibiting the germination[2] inhibited growth of the bacteria as well.

The behaviour of seeds not more than a year old of four hundred species and varieties of higher plants belonging to seventy families has been observed by the method above described. In every case eight bacterial strains were used as test micro-organisms. Gram-positive: *Bac. cereus* var. *mycoides*, *Bac. megatherium* 208, *Bac. subtilis* var. *panis*, *Staphylo-*

coccus aureus; and Gram-negative: *Aerobacter aerogenes, Erwinia carotovora, Shigella flexneri VI* and *Xanthomonas malvacearum*.

The seeds of thirty-six species of plants yielded positive results. In most cases the effect was selective, the diffusing compounds inhibiting the increase of only the Gram-positive bacteria. The inhibitor of the *Fraxinus* species proved effective also against most Gram-negative test micro-organisms. The effect on the Gram-positive bacteria was of similar intensity.

With *Bac. cereus* var. *mycoides*, clear zones of a diameter of more than 1 cm. were produced by the seeds of the following species: *Abies alba, Aristolochia clematitis, Geranium silvaticum, Hypericum elegans, Juniperus chinensis, Kniphofia aloides, K. hybrida, K. praecox, K. tuckii, K. uvaria*.

Zones of 5 mm. diameter or more: *Aristolochia fimbriata, Atriplex hortensis, A. nitens, Cannabis sativa, Chenopodium polyspermum, Consolida ajacis, C. orientalis, C. regalis, Fraxinus excelsior, F. pennsylvanica, Maclura aurantiaca, Pinus strobus*.

Zones of less than 5 mm.: *Amaranthus ascendens, Chenopodium album, Ch. bonus, Ch. urbicum, Kochia scoparia, Picea alba, P. excelsa chlorocarpa, Pinus nigra, Pseudotsuga douglasii, P. taxifolia, Stachis annua, Verbena canadensis, V. officinalis*.

Certain seeds—generally known to contain antibacterial compounds (*Gynocardia, Hydnocarpus*[3], Cruciferae[4–6])—gave no positive results in the present study. The reason is that the active compounds are located in the inner parts of these seeds and are, as a rule, released only by ferments[5,6].

The diffusing compounds observed in the present cases, except the inhibitor of the *Fraxinus* species, are localized in the seed-coat. The active substance of the seeds of *Kniphofia* species has been isolated. Isolation of active substances from other seeds has been started. The detailed results will be dealt with elsewhere.

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Alternaria within the Pericarp of the Wheat Seed

In 1951, Miss Hyde[1] obtained from the basal internode (about 1–2 in. long) of flowering stems of Barsée wheat and from stems immediately below the inflorescence, under aseptic conditions in culture plates, *Alternaria tenuis* in 40 and 43 stems out of 70. In 1953, I[2] published a note on the apparent symbiotic nature of *Alternaria tenuis* within the pericarp of some local wheat seeds. Since then, in the winters of 1953 and 1954, I carried out aseptic culture of our common wheat seeds within two sterilized glass chambers where aseptic seedlings from malt agar tubes were planted on sterilized manured soil, making provision for circulation of pure air which was sucked through cotton-wool in glass tubes by means of a water tap suction pump, and sterilized water, passing through a horizontal glass tube inserted through an air-tight hole on the chamber wall, dropped direct on the seedlings half an hour every day for two and a half months from early November. The two glass chambers were quite similarly fitted. In one glass chamber aseptic seedlings were prepared in the following way: wheat seeds were surface-sterilized with 0·1 per cent mercuric chloride for six minutes, washed three times in sterilized distilled water and planted in malt-agar tubes where they germinated into seedlings in the course of four days. In the other glass chamber *Alternaria tenuis* was eliminated from the aseptic seedlings in the following way: wheat seeds in sterilized water in a test-tube were exposed to a temperature of 53·5°–54° C. in a water-bath for ten minutes to kill *Alternaria* within the seed coat; they were then cooled, surface-sterilized with 0·1 per cent mercuric chloride for six minutes as before, washed three times in sterile distilled water and planted into malt-agar tubes for germination into seedlings. The temperature of two glass chambers was 10–15 degrees higher than that of the laboratory and they were usually in a very humid condition during the experiment. In the course of a month and a half it was found that the growth of plants and number of tillers under sterilized conditions in the glass chamber where *A. tenuis* was not eliminated were more vigorous and more numerous than those of the plants in the chamber where the *Alternaria* was eliminated by hot-water treatment. Thus, the presence of *Alternaria tenuis* within the wheat plants in this case seems distinctly helpful.

Discussing the black point disease of wheat in the United States, Hansen and Christensen[3] in 1953 held from replicated tests that "*Alternaria* infection does not cause any appreciable reductions in stand or any seedling blight and that *Alternaria* has little, if any, deleterious effect on the value of the infected grain for seed". Their final conclusion was that "*Alternaria*, although the most prevalent fungus, was either non-pathogenic or weakly pathogenic and never caused seedling blight of wheat in the greenhouse or field".

But in February 1955 there was a report[4] of severe leaf spot disease of 'durum' wheat by an *Alternaria* sp. from Cuttack (Orissa), Central Rice Research Institute; the brown spotting on leaves, which from a distance looked like rust, was so extensive that ultimately the yield was considerably reduced, leading to almost a complete failure of wheat crop. In this case the disease was strictly confined to 'durum' wheat and common varieties of wheat were free from it. A similar outbreak of severe leaf spot disease of 'durum' wheat by *Alternaria* sp. was noted by Mehta[5] in 1950 from the Research Farm of Kanpur, Uttar Pradesh of India. He established the parasitic nature of that *Alternaria* sp. by inoculation experiment on 'durum' variety with pure culture of his isolation of *Alternaria* from leaf-lesions of the wheat. Mehta held that the disease was seed-borne. Some data, however, are lacking, if the seeds sown in the field in both cases originally harboured the same *Alternaria* sp. within the seed coat of 'durum' wheat, and the species of *Alternaria* here has not been determined. In this connexion it may be remarked that no sharp lines of demarcation can be drawn between symbiotic interrelationship and antagonistic effects and that symbiosis and parasitism (antagonism) have much in common both physiologically and morphologically; the one may be converted into the other by a comparatively slight change of circumstances.

Studying spore production by *Helminthosporium avenae*, Grainger[6] found "no correlation between spore-liberation and general climatic conditions, i.e., temperature, relative humidity and wind velocity",

contrary to the experience of plant-pathologists in many plant diseases. He suggests that as the factor cannot be climatic in this case, "an investigation of conditions within the host plant itself is most likely to provide an explanation". I think in wheat rust similar study of conditions of growth within the wheat plant may yield some clue to the main problem of eradication. So far, at wheat rust study centres no attention in this direction seems to have been paid.

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Effect of Crowding during the Larval Period on the Determination of the Wing-form of an Adult Plant-hopper

The effect of crowding on the physiological and morphological characters of larvæ or adult has attracted much attention. Comprehensive reviews have been published by Allee[1], and recently by Chauvin[2]. The latter distinguished two categories in the general effect of crowding, "l'effet de masse" and "l'effet de groupe", which had been proposed by Grassé. Bonnemaison[3], in his studies on the factors affecting the appearance of the winged form in aphids, and Badonnel[4], working on the complete development of the wings in Psocoptera, found that the most important effect of crowding occurs during the developmental period.

I am investigating the factors determining the wing-form, macropterous or brachypterous, of plant-hoppers, and I have found that crowding during the larval period plays an important part in the determination of wing-form in the brown plant-hopper, *Nilaparvata lugens* Stål.

The brown plant-hopper is a serious pest of the rice plant in Japan. The macropterous form has normal fore- and hind-wings; but the brachypterous form has the fore-wings of half the normal length and rudimentary hind-wings, and this form consequently cannot fly. Macropterous males and females appear at first in the paddy fields in early summer. Brachypterous females appear afterwards and increase in number during the summer and autumn. By late autumn, when the rice plants ripen, the macropterous form becomes prevalent again. Brachypterous males appear in late summer and autumn but are less frequent than females.

Larvæ were put into test-tubes (2 cm. in diameter and 17·5 cm. in length) within 24 hr. of hatching, with a leaf blade of rice plant in each for food. A few drops of water were poured into each tube. Food and container were renewed at intervals of 1, 2 and 4 days in each series of density.

The result is shown in Fig. 1. At the lowest density the figures differ extremely with sex; all emerged females are brachypterous and males are macropterous. With increase of density, the percentage of the macropterous females increases and reaches almost 100 per cent at a density of 20. On the other hand, in

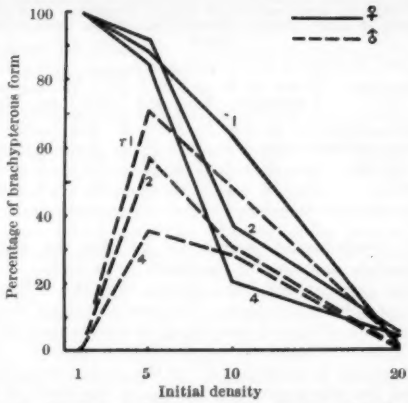

Fig. 1. Percentage of the brachypterous form of both sexes resulting from a breeding experiment in which the initial density and interval of renewal of the food and container were varied

the males, the brachypterous form appears in the middle range of density. At greater densities, the macropterous form increases again with the density in parallel with the females. Therefore, the optimal density for the appearance of the brachypterous male can be determined.

On the other hand, the effect of freshness of food and change of container has also to be appreciated. When the interval of renewing food and container is prolonged, the appearance of the macropterous form is accelerated in both sexes. This effect is most clearly shown in the middle range of density. It seems probable that the larvæ are at the critical state for determining their form at that density.

The larval period of the various forms is shown in Table 1; that for the brachypterous form of both sexes is shorter than that for the macropterous form. The former shows a rather constant period even at high densities, whereas that of the latter shows a lengthening effect. Examined in more detail, it is found that at the density of 5 at which the brachypterous male appeared in highest proportion, this form is the group having the shortest period of larval development. This larval period is shorter than that of the macropterous male, which appeared exclusively at a density of 1. This acceleration of

Table 1. Duration of the Larval Development of the Various Forms resulting from a Breeding Experiment in which the Initial Density and Interval of Renewal of the Food and Container are Varied. *B* denotes the Brachypterous Form and *M* the Macropterous Form

Interval of renewal = 1 day

Form and sex \ Density	1	5	10	20
		14·2	14·1	
B♂		14·5	16·1	17·2d.
M♂	14·7	15·5	16·6	18·0*
B♀	15·2	15·5	17·5	18·9
M♀				
$r = 2$				
		14·2	14·3	
B♂		14·2	15·2	17·5
M♂	14·5	15·2	15·7	
B♀	15·3	16·3	17·4	19·7
M♀				
$r = 4$				
		13·8	14·8	
B♂		14·6	15·4	17·0
M♂	14·5	15·1	16·0	18·0*
B♀	15·1	15·4	17·2	18·2
M♀				

* Only one obtained

Table 2. Number of Adults of the Various Forms resulting from Breeding with the Leaf Blade immersed in Various Solutions of Salt. Initial Density was 5 per Tube in Each Block

Solution	No. of replicates	No. of adults emerged				
		$B\delta$	$M\delta$	$B♀$	$M♀$	Total
Copper sulphate	10	0	0	0	0	0
Ammon. sulphate	10	1	26	3	17	47
Mag. sulphate	10	7	16	15	9	47
Pot. chloride	10	11	16	14	9	50
Control	10	13	13	19	2	47

larval development seems to be due to mutual stimulation among the members in a tube.

Other experiments have shown that the wilting of the host plant produces the macropterous female without the effect of crowding, accompanied by the considerable elongation of the larval period. This fact seems to be responsible for the prevalent appearance of the macropterous female in the field in late autumn.

Various solutions of salts were used instead of water in the test-tubes for examining their effectiveness for the determination of the various forms. The concentration of each solution was 0·05 mol. The initial density used was 5. Food and container were renewed every day and no wilting of the leaf blade was observed, except when copper sulphate solution was used; in that case all larvæ died in a few days (Table 2). These solutions show, more or less, the effectiveness on the production of the macropterous form in both sexes. Parallel decrease in the percentage of the brachypterous form is clearly shown in both sexes, though the absolute figures for the brachypterous females in each treatment always exceed those of males.

The observations lead to the following conclusions.

(1) Low density under favourable conditions of food supply during the larval period is necessary for the appearance of the brachypterous female. On the other hand, optimal density under favourable conditions of food supply produces the brachypterous male. The mechanism of the different responses of the sexes to crowding remains to be found.

(2) Optimal crowding accelerates the development of the larvæ, and this fact seems to be responsible for the mechanism inducing the appearance of the brachypterous male at the optimal density.

(3) Wilting of the host plant, overcrowding, contamination due to crowding and solutions of several salts have the effect of producing the macropterous form, and this effect is followed by lengthening of the developmental period of the larvæ subjected to these conditions.

(4) Factors causing the appearance of the brachypterous form must be studied in parallel with those leading to the appearance of the macropterous form, especially the males, as shown in the present communication.

The advice of Prof. S. Utida of this Laboratory is gratefully acknowledged.

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An Apparent Reaction of Fish to Linear Accelerations

It has been reported that fish do not appear to react to rectilinear accelerations[1]. However, they have the sense organs to detect such movements; the otolith organs of the thornback ray are sensitive to linear translations in all three planes of space[2] and teleosts take up compensatory positions when subjected to centrifugal force[3]. Some experiments were therefore made to re-examine the reactions of fish to rectilinear accelerations, blinded minnows, goldfish and naturally blind cave characins, *Anoptichthys jordani*, being used in the preliminary observations. The fish were placed in an enclosed 'Perspex' tank, completely filled with water, and mounted on a rubber-wheeled chassis. They appeared to turn about when the tank was accelerated along a bench by hand.

The reactions of blind goldfish were then studied in a more quantitative manner. A fish was introduced into an enclosed 'Perspex' tank, 60 cm. long, 30 cm. × 15 cm. in section, which was filled with water. The tank was housed in a welded angle-iron chassis fitted with flat rubber-tyred wheels running on a 4-m. long railway made from ¾-in. steel rod firmly attached to sleepers. The chassis was attached to a rope which ran over two pulley wheels so arranged that the vertical fall of heavy weights would accelerate the tank horizontally along the railway. When the weights hit the ground, the forward movement of the tank was checked by a rope attached at one end to a wall and at the other to the tank by a short length of rubber tubing. A range of accelerations and decelerations was covered by varying the weights and the forward run of the tank. The movement of the tank relative to the ground and that of the fish relative to the tank was recorded by a 16-mm. ciné camera mounted vertically above the railway. Releases were only made when the fish was in mid-water and well clear of the sides of the tank, and when it was swimming more or less in a straight line either with or against the movement of the tank.

The results showed that blind goldfish would turn about when suddenly stopped going forward, or when suddenly started backwards, but not when started going forwards or when stopped going backwards. An analysis of two typical results is given in Figs. 1 and 2. The orientation of the fish is given relative to the longitudinal axis of the tank, a bearing of 0° indicating that the fish was facing in the direction of the tank's movement. In Fig. 1 the tank was released so that the fish was accelerated backwards and it turned about. When the tank slowed down, the fish was decelerated while travelling forwards and turned again. In Fig. 2 there was no reaction to an acceleration when the fish was going forward, but the fish turned on deceleration. A positive reaction was thus only observed when the otolith organs were displaced anteriorly, as indicated diagrammatically in the figure.

The threshold acceleration to induce a reaction was high, positive results being obtained only with accelerations or decelerations greater than 160–200 cm./sec./sec. In both Figs. 1 and 2 it will be seen that the tank recoiled after its forward movement was checked. In some experiments a fish was observed to turn both when the tank slowed down and when the recoil movement slowed down.

While there is an apparent reaction of blind goldfish to linear accelerations, the results do not show con-

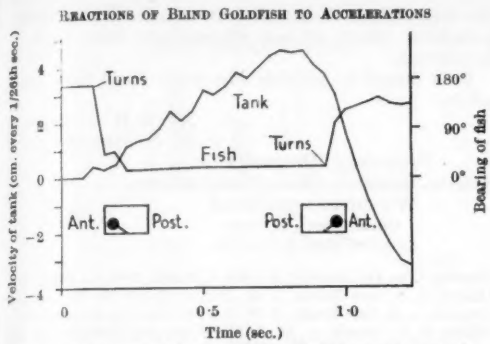

Fig. 1. Fish accelerated backwards. Acceleration, 170 cm./sec.²; deceleration, 364 cm./sec.².

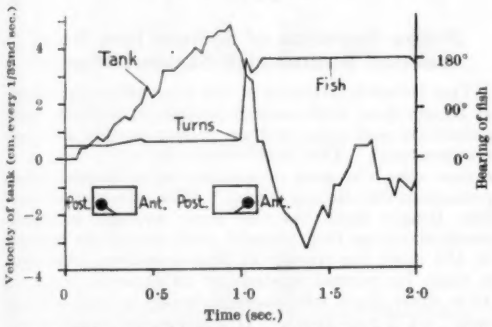

Fig. 2. Fish accelerated forwards. Acceleration 176 cm./sec.²; deceleration, 710 cm./sec.².
The fish only appears to turn when the otolith organs are displaced anteriorly

clusively that the stimulus to which the fish responds is labyrinthine in origin. With these particular fish it was not possible to release the tank when they were at right angles to its line of movement, as they swam for the most part up and down the length of the tank. Furthermore, unless the ciné camera is mounted on the chassis itself, it is not possible to detect movement of the water relative to the fish, or to study the nature of any eddies or swirls that might be set up in the tank, all of which might stimulate the fish. In the early stages of this work, it was thought unwise to risk the camera in this way; but further experiments with other fish are now planned to look into these points.

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The Basement Membrane–Elastica System of the Dermo-Epidermal Junction

Reports (based on electron microscopy)[1] of the presence of a subepidermal basement membrane in human skin conflict with the orthodox histological view[2] that dermo-epidermal adhesion is effected by an interlocking of the subepidermal 'reticular fibres' with the foot processes of the basal cells, and that no basal membranous structure apart from this layer of reticulin exists.

A more satisfactory account of the stabilizing mechanism of the human dermo-epidermal junction can now be offered.

The basic dye alcian blue used in buffered aqueous solutions of *p*H 1·2–2·0 will stain certain tissue structures which are not generally basophilic even at higher *p*H levels. These structures comprise collagenous and reticular tissue, and various basement membranes (for example, subepidermal, vascular sub-endothelial, glomerular, renal tubular); and while previous treatment with testicular hyaluronidase prevents staining of the fibro-reticular tissue, basement membrane staining is unaffected. These results may indicate the presence of two chondroitin sulphate – protein complexes, one sensitive and the other resistant to hyaluronidase, like those isolated from rabbit skin[3]. The subepidermal basement membrane is also morphologically distinct from subepidermal reticulin; it appears as a delicate continuous tightly wrinkled band which is regular in thickness and discrete, whereas the reticulin forms a coarser interrupted layer of variable thickness which merges on its deep aspect with the fine dermal collagenous tissue.

Basement membranes are usually found in close association with reticulin; but in other respects (discreteness, optical homogeneity, apparent tenacity) basement membranes seem to have more in common with elastic tissue and even stain as elastica in certain sites (for example, around sweat glands).

It has been found that in tissue sections treated with the 'Mallory bleach', alcian blue will reveal certain additional tissue structures, some keratinous and others elastic. The elastic group comprises the sheaths of all those relatively coarse elastic fibres and laminæ demonstrable by recognized methods together with other very fine membranes and fibres, which in sections counterstained with orcein are often clearly continuous with the coarser fibres or their sheaths. In particular, the thin elastic fibres, which fan out as branches of the papillary layer of the dermal elastic plexus and run up towards the epidermis, are seen to consist of a brown orcein-

Fig. 1. The subepidermal basement membrane–elastica system. Hyaluronidase; permanganate bleach; alcian blue, *p*H 1·2 orcein. × 870

stained core (which tapers away into invisibility before the dermo-epidermal junction is reached) and of a blue sheath, which terminally remains visible as a delicate band and carries on to fuse with the blue subepidermal basement membrane.

Thus it appears that the epidermis is attached to the corium by continuity of the dermal elastic plexus with the subepidermal basement membrane, which itself must either be cemented to, or actually incorporate, the cell membrane of the inferior surface of each basal cell.

Finally, as basement membranes stain more strongly with alcian blue if the bleaching procedure is first performed, they may also contain that elastic tissue component which binds alcian blue after oxidation by permanganate. Basement membranes and elastica may form a morphological and chemical continuum analogous in some ways with the reticulin–collagen system.

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Demethylation of Dimethylnitrosamine in Rats and Mice

Dimethylnitrosamine is a powerful liver poison and carcinogen[1,2], the mode of action of which is being studied in these Laboratories. As part of this programme, we have investigated the metabolic products from rats and mice using (^{14}C) dimethylnitrosamine[3].

From both rats and mice the main radioactive product is expired carbon dioxide. Thus 50 mgm. of dimethylnitrosamine/kgm. were injected subcutaneously into a mouse, and 6 hr. after injection 65 per cent of the injected carbon-14 was recovered as expired carbon dioxide. The carbon-14 recovered as carbon dioxide from rats injected at the same dose-rate is shown in Table 1. About 40 per cent is recovered in the first 8 hr., after which only trivial amounts are expired. The remainder of the carbon-14 appears to be fairly evenly distributed in the tissues at the end of the experiment, except for some 7 per cent which appears in the urine.

Table 1. Percentage of Total Carbon-14 injected into Rats recovered as Expired Carbon Dioxide

Time (hr.)	0·5	1	2	4	8	12	24
Per cent recovered	1·1	4·1	11·3	29	41	42	45
	0·9	3·3	10·5	21	37	42	44·4

These results indicate that dimethylnitrosamine is demethylated, presumably via formaldehyde, which would explain the expiration of much of the carbon-14 and the very general distribution of the remainder. The metabolism is thus closely analogous to that of the several N-methyl substituted aminoazobenzenes studied by Miller *et al.*[4].

The rapidity with which dimethylnitrosamine is metabolized makes it necessary to consider the possibility that the biochemical lesion is produced by a metabolite, and not by dimethylnitrosamine itself. The first signs of histological damage[1] to the liver have been observed only at a time when the degradation of dimethylnitrosamine is practically complete, which is not inconsistent with such a hypothesis.

It is hoped to publish this work more fully elsewhere.

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Active Secretion of Sodium Ions from Isolated Sodium-rich Skeletal Muscle

The isolated sartorius of the frog, when immersed in Ringer fluid with normal potassium content, loses potassium and gains sodium rather rapidly at room temperature[1]. This also occurs at 0° C., but at a slower rate, the gain of sodium being greater when potassium-free Ringer is used[2]. When this potassium-free Ringer fluid has the same average inorganic composition as frog plasma[1] with a sodium content of 104 mM, the change in muscle sodium overnight is from its normal content of 24 m.equiv./kgm. to 47 m.equiv./kgm. (the average change in weight being only −1·2 per cent). If companion muscles are similarly treated and then immersed at room temperature for 2 hr. in similar fluid containing 10 m.equiv. potassium / litre, but the same concentration of sodium, there is no appreciable excretion of sodium. Steinbach's conclusions[3] to the contrary have been shown to depend very largely, if not altogether, on a faulty statistical procedure.

Similarly, if the potassium-free fluid contains 120 m.equiv. sodium/litre and the re-immersion fluid has the same sodium concentration but 10 m.equiv. potassium/litre, there is no net excretion after two hours[4].

Confirming the observations of Desmedt[5], on the other hand, we found that if the potassium-free Ringer fluid contained 120 m.equiv. sodium/litre and the companion muscles are re-immersed in fluid containing 104 m.equiv. sodium/litre with 10 m.equiv. potassium/litre, there is a marked excretion of sodium, far beyond what could be explained simply by passive diffusion from interspace fluid or injured fibres.

The magnitude of the changes are shown in the accompanying diagram (Fig. 1, *A*, *B* and *C*). The heights of the columns express the average sodium content of the fibre water. In calculating this concentration, an effective interspace volume of 0·13 litre per kilogram muscle is assumed[1]; also an additional 8 m.equiv. of sodium is considered as held in some external fibre region[4]. The total sodium external to the fibre water and represented as m.equiv./kgm. muscle is thus approximately 20 per cent of the external sodium concentration. (For the relative changes described here it makes no essential difference whether the above procedure is adopted or whether one regards the total sodium minus the interspace sodium as existing in the fibre water.)

The number of experiments and muscles used in Fig. 1 is as follows: *A* (120/120) 12 experiments,

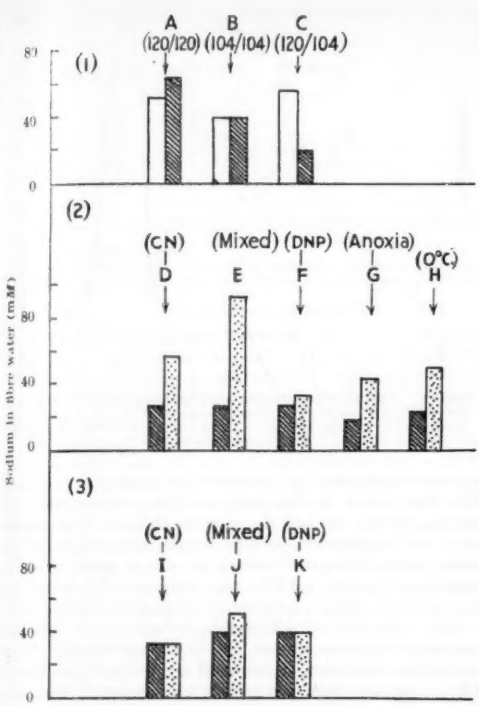

Fig. 1. (*A*) (120 : 120): Muscles immersed in potassium-free Ringer–Conway fluid (containing 120 m.equiv. sodium/litre) and reimmersed at room temperature for 2 hr. in similar fluid containing 120 m.equiv. sodium/litre and 10 m.equiv. potassium/litre. (*B*) (104 : 104): As in (*A*); the first and second fluids containing 104 m.equiv. sodium/litre and 10 m.equiv. potassium/litre. (*C*): (120 : 104): As in (*A*); the second fluid containing 104 m.equiv. sodium/litre and 10 m.equiv. potassium/litre

Fig. 2. (*D*): As in (*C*); one second immersion fluid containing 2 m*M* cyanide. (*E*): As in (*C*); mixed inhibitors (cyanide, 2.4-dinitrophenol and iodoacetate, each 5 m*M*) in one second fluid. (*F*): As in (*C*); 2.4-dinitrophenol (2 m*M*) in one second fluid. (*G*): As in (*C*); one second fluid free of oxygen. (*H*): As in (*C*); one second fluid at 0° C.

Fig. 3. (*I*): As in (*B*); cyanide (2 m*M*) in one second fluid. (*J*): As in (*B*); mixed inhibitors in one second fluid. (*K*): As in (*B*); 2.4-dinitrophenol (2 m*M*) in one second fluid

72 muscles; *B* (104/104) 51 experiments, 306 muscles; *C* (120/104) 55 experiments, 330 muscles. (The symbol 120/120 signifies that the sodium content of the potassium-free Ringer was 120 m*M*, as also that of the second immersion fluid, and similarly with the other symbols.)

The considerable fall of muscle sodium in *C* is very striking and such excretion we have found invariably under these conditions. The active nature of this excretion involves metabolic energy, as is shown by the effect of inhibitors (Fig. 2). The conditions were as in Fig. 1*C*, that is, immersion in the potassium-free Ringer fluid containing 120 m.equiv. sodium/litre and re-immersion in 104 m.equiv. sodium/litre with 10 m.equiv. potassium/litre. The hatched columns give an average sodium content after 2 hr. of the second immersion without inhibitor. It will be seen from Fig. 2*D* that when 2 m*M* cyanide is present in the re-immersion fluid, there is considerable inhibition of the sodium excretion, the level after 2 hr. being practically unchanged with respect to the muscle content after overnight immersion (13 experiments, 78 muscles). Fig. 2, *G* and *H* show the effect of anoxia and of 0° C. (4 experiments in each, 48 muscles). It will be seen that there is considerable inhibition here also and very little, if any, active excretion. Fig. 2*F* shows the effect of 2.4-dinitrophenol inhibition (10 experiments, 60 muscles) and is of particular interest because, although the inhibitor is in 2 m*M* strength, its effect is very slight. Fig. 2*E* shows the effect of 5 m*M* cyanide, 5 m*M* 2.4-dinitrophenol and 5 m*M* iodoacetate present together (20 experiments, 120 muscles). In this case, not only is there no active excretion, but there is an increased uptake of sodium, possibly due to some degree of damage to the membranes.

The series in Fig. 3 are in striking contrast to these results. In these experiments, the re-immersion fluid contains the same sodium content as the potassium-free Ringer, namely, 104 m.equiv. sodium/litre. It will be seen that 2 m*M* cyanide has no effect (13 experiments, 78 muscles), neither has 2.4-dinitrophenol (10 experiments, 60 muscles). Also the mixed inhibitors have a comparatively small effect, the sodium content being somewhat increased (20 experiments, 120 muscles).

The results shown in Figs. 1*A*, 1*B*, 3*I*, 3*J* and 3*K* are quite in accordance with the results of Keynes and Maisel[6], and although these showed a considerable flux of sodium-24 across the membrane, the above results suggest that such fluxes are largely, if not entirely, explained by exchange diffusion as described by Ussing[7].

The sodium content of the muscles has been expressed on the weights after the first immersion. If one considers here that the active net extrusion of sodium from sodium-rich muscles depends on the presence of oxygen and is practically completely inhibited by cyanide (2 m*M*) but very little, if at all, by 2.4-dinitrophenol (2 m*M*), it is in full accord with what one would expect from the action of a redox pump[8].

In a recent communication in *Nature*[9], Shaw and Simon reported results of experiments in which sodium-rich muscles were immersed in Ringer fluid, diluted 1 : 1 with isotonic glucose solution, and sodium-levels were expressed in a somewhat similar manner to the way adopted here. They found considerable emergence of sodium from the sodium-rich muscles. This, however, was not appreciably inhibited by cyanide, and hence would seem to be different in kind from the results described here, in which even 2 m*M* cyanide completely inhibits excretion. The sodium emergence described by these workers may be largely of a passive kind, though it would appear to be much reduced by low temperature. The findings are considered in greater detail elsewhere[10].

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Concentration of Thiocyanate labelled with Sulphur-35 in the Thyroid of the Hamster

Thiocyanates are known to inhibit the concentration of iodide by the thyroid. We have found that labelled thiocyanate is concentrated in the follicles of the hamster's thyroid. Adult hamsters were given ^{35}S-thiocyanate (150 μc. with 100 μgm. of carrier) by intramuscular injection. The thyroid was removed 1 hr. later and dried from the frozen state at − 40° C. Contact autoradiographs were then made from sections of the dried tissue[1]. Patches of blackening were seen on the autoradiographs, corresponding to the areas of colloid in the section (Fig. 1). The density of the photographic grains over the centres of the follicles varied from 2·1 to 4·9 times the density over the centres of blood-vessels, the density over the smaller areas of colloid tending to be greater than that over the larger areas.

Thyroids were removed from other hamsters 1 hr. after injection of ^{35}S-thiocyanate and the radioactivity compared with that in the plasma and whole blood (unpublished work). The ratio of the concentration of sulphur-35 in the thyroid to that in the plasma averaged 0·57, and in the thyroid/blood it averaged 0·56. Portions of thyroid taken from the same hamsters were homogenized with water, and the whole homogenate chromatographed on paper with the solvents recommended by Pollard and McOmie[2]. The radioactivity on the chromatogram was found to be confined to two well-defined peaks, one at R_F 0·10 (the R_F value of sulphate ion in the solvents used) and the other at R_F 0·75 (the R_F value of thiocyanate ion) (Fig. 2). The first peak of radioactivity accounted for 5–15 per cent and the second peak for about 85 per cent of the total on the chromatogram. Chromatograms made from plasma taken at similar intervals after injection of ^{35}S-thiocyanate showed 95 per cent of their radioactivity at R_F 0·75.

We conclude that thiocyanate ions are concentrated in the follicles of the thyroid as the unbound ion, some of them undergoing chemical change in the thyroid, probably by oxidation to unbound sulphate. The low value of the ratio of the concentration of sulphur-35 in whole thyroid to that in the plasma may be explained by the small proportion of the total mass of thyroid tissue in which selective concentration occurs, and by the presence of muscle and connective tissue removed with the thyroid.

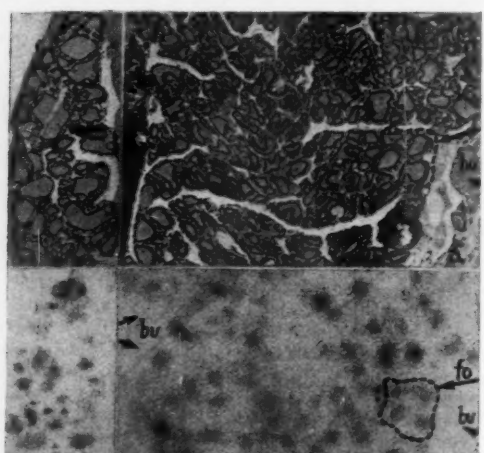

Fig. 1. Thyroid of hamster. (*a*) Sections stained with hæmotoxylin and eosin. (*b*) Autoradiographs from same sections. *fo*, Group of follicles; *bv*, blood-vessel. Corresponding areas shown on autoradiograph

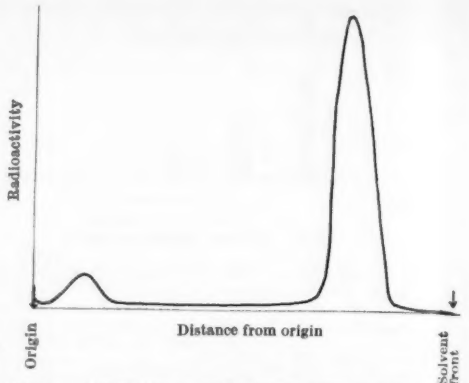

Fig. 2. Distribution of radioactivity along ascending paper chromatogram made from homogenate of thyroid 1 hr. after injection of ^{35}S-thiocyanate. Solvents: butanol, pyridine, water and ammonia

The pattern of blackening shown by ^{35}S-thiocyanate is similar to that shown by radioiodide when thyroxine synthesis is blocked by propyl thiouracil[3]. This suggests that the inhibitory action of the thiocyanate ion on the concentration of iodide by the thyroid is due to competition between the two ions for the same transport mechanism.

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Octadecadienoic Acids of Lamb Caul Fat

In the course of investigations on the fat of rumen contents[1], it was observed that the iodine values of C_{18} unsaturated fatty acid fractions were substantially higher than could be accounted for by the content of diene and triene acids determined by alkali isomerization[2]. However, the amounts of material isolated were small, and in order to investigate further the acids responsible for this anomaly, the methyl esters of the C_{18} unsaturated acids from the caul fat of lambs two to three weeks old, earlier described[3], were used.

Crystallization of 52·5 gm. of the C_{18} concentrate three times at −60° C. from ten volumes of acetone yielded 12·0 gm. (iodine value 145·3) of soluble constituents. These were chromatographed[4] on silica gel to yield concentrates of diene acids.

Table 1. Composition of C_{18} Diene Concentrates from Lamb Caul Fat

Fraction	Weight (gm.)	Iodine value (Wijs 1 hr.)	Diene (%)* (a)	Diene (%)* (b)	Triene (%) (a)	Triene (%) (b)
1	0·65	110·7	—	—	—	—
2	0·66	150·7	—	—	—	—
3	0·50	163·1	33·8	89·5	Nil	Nil
4	0·54	165·7	29·4	92·4	Nil	Nil
5	2·30	182·0	29·5	89·0	12·7	11·0
6	0·53	237·6	—	—	—	—

* In all cases conjugated diene acids amounted to less than 0·6 per cent.
(a) From isomerizations.
(b) Calculated from iodine values, assuming fractions 3 and 4 to contain mono-ene and diene, and fraction 5, diene and triene acids only.

It is apparent that the content of diene acids estimated by isomerizations is about one-third that calculated from the iodine values. This suggests the presence of considerable proportions of non-conjugable diene acids.

To obtain further information 0·21 gm. of fraction 5 was ozonized in 15 c.c. of chloroform at −10° C., and the ozonides taken to dryness *in vacuo* at room temperature. After standing for two days with perhydrol, the aqueous solution was extracted with light petroleum (boiling point 40–60°). The water-soluble acids were taken to dryness and chromatographed on silica gel according to the procedure of Marvel and Rands[5]. The acids were identified by means of their peak effluent volumes as compared with those of a standard mixture. Expressed as a percentage of the original ester ozonized, they were: malonic 1·6, succinic 8·2, glutaric 2·9, adipic 3·1.

The identity of succinic acid was confirmed by means of its melting point, along with that of its diphenacyl ester.

Since free dicarboxylic acids could only come from oxidative cleavage of the double bonds, the presence of such acids of longer chain-length than malonic in the products of ozonolysis of fraction 5 suggests that there are present in lamb caul fat isomers of linoleic acid having double bonds separated by two or more methylene groups. Van der Veen[6] has shown that isomers of linoleic acid are produced on catalytic hydrogenation of methyl linolenate, while Rebello and Daubert[7] demonstrated that three of these isomers were the 8,14-, 9,15- and 10,14-octadecadienoic acids. Since Reiser[8] has shown that polyunsaturated acids are hydrogenated by rumen micro-organisms, the presence of isomers of linoleic acid in lamb caul fat could be explained by assuming their formation in the rumen and deposition in the depot fat.

The isomers of linoleic acid present in the caul fat amount to 1·2 per cent of the total fatty acids.

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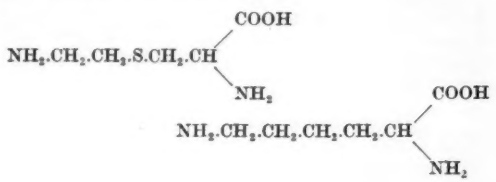
A New Synthetic Substrate for Trypsin and its Application to the Determination of the Amino-acid Sequence of Proteins

The problem of the determination of the amino-acid sequence of a protein would be greatly simplified if methods were available for specifically hydrolysing peptide bonds involving a particular amino-acid. No satisfactory chemical method of doing this has been found, and the only controlled methods of hydrolysis available at present are digestion by proteolytic enzymes, in particular chymotrypsin and trypsin. It seemed possible that useful results might be obtained if a particular amino-acid side-chain could be modified in such a way as to resemble as closely as possible the side-chain involved in the specificity requirements of some enzyme. If the resemblance could be made sufficiently close, the enzyme might then hydrolyse the adjacent bond.

The hypothesis has been tested by studying the action of trypsin on the polymer of S-(β-aminoethyl-) cysteine. The side-chain of this amino-acid bears a strong resemblance to that of lysine, a $—CH_2—$ group being replaced by a sulphur atom:



S-(β-aminoethyl-) cysteine Lysine

A sulphur atom occupies much the same volume as a $—CH_2$-group, and the bond angle for sulphur is 100° compared with the 109·5° for a tetrahedral carbon atom. The preparation of the amino-acid polymer followed standard procedures and in outline was as follows. Cystine was reduced by sodium in liquid ammonia and coupled with N-carbobenzoxy β-bromoethylamine to give S-(β-carbobenzoxyaminoethyl-) cysteine. This was then converted to the dicarbobenzoxy derivative and hence via the acid chloride to the N-carboxyanhydride of S-(β-carbobenzoxyaminoethyl) cysteine, which was polymerized by heating at 110°. Removal of the protecting carbobenzoxy group gave the hydrobromide of the polymer of S-(β-aminoethyl-) cysteine. This was soluble in water but could be precipitated from aqueous solution by the addition of ethanol. Fig. 1 shows chromatographic evidence that the polymer is an excellent substrate for trypsin.

It has also been shown that the thiol groups of reduced wool will react quantitatively with β-bromoethylamine in 0·5 *M* sodium carbonate at room temperature overnight. S-(β-aminoethyl-) cysteine resembles lysine so closely in its chromatographic behaviour that it is not possible to separate them on a two-dimensional chromatogram using butanol/acetic acid and phenol/ammonia. However, it was shown that the hydrolysate of wool treated in this way gave a spot which reacted with iodoplatinate and occurred in the position occupied by lysine, which suggests strongly that the cysteine residues of the reduced wool have been converted to S-aminoethyl cysteine residues by the treatment. Although direct evidence on a protein has not yet been obtained, it would seem likely that peptide bonds involving

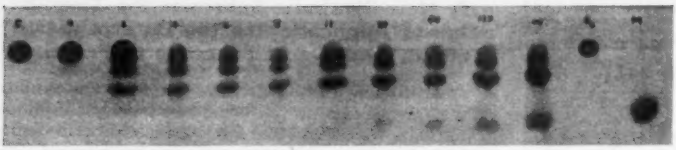


Fig. 1. Chromatogram showing hydrolysis of polymer of S-(β-aminoethyl-) cysteine by trypsin. Experimental conditions: 19·4 mgm. polymer hydrobromide/ml., 0·08 mgm. crystalline trypsin (Worthington)/ml., 0·1 *M* sodium bicarbonate (final *p*H 7·4), *T* = 26°. The numbers 0–120 refer to the time in minutes before spotting the sample on the paper, the reaction being stopped by the prior application of a spot of glacial acetic acid. The ∞ symbol refers to a solution from a similar experiment which had been left at laboratory temperature for twelve days. C_1 and C_2 refer to control solutions of the polymer in the absence of enzyme at times 0 and 120 min. respectively, while *M* is a sample of the monomer S-(β-aminoethyl-) cysteine. The chromatogram was run on Whatman No. 1 paper for five days using butanol/acetic acid/water/pyridine (30 : 6 : 24 : 20) as solvent (ref. 2)

cystine or cysteine residues in proteins will be specifically split by trypsin if they are converted to S-aminoethyl cysteine residues.

It is proposed to use this technique, first in an attempt to confirm earlier conclusions on the mode of reduction of insulin[1], and secondly in an endeavour to obtain information on the location of cystine residues in the wool proteins.

It might well be that the analogous O-β-aminoethyl derivative of serine would behave in a similar fashion if some simple method of converting the serine side-chains were available. It is not intended to investigate this possibility at present.

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The Major Anthocyanin Pigments of the Wild Strawberry (*Fragaria vesca*)

Although it has been definitely established that cultivated strawberries contain pelargonidin-3-monoglucoside as the major anthocyanin[1,2] and cyanidin-3-monoglucoside as a minor component[3], there is still some question about the identity of the pigments of *Fragaria vesca*. As a result of qualitative tests, Robinson[4] suggested in 1934 that the anthocyanin of *F. vesca* is pelargonidin-3-monogalactoside. In a more recent paper, Robinson and Smith[3] described a chromatographic procedure for distinguishing pelargonidin-3-monoglucoside and the galactoside, but left the identity of the anthocyanins of wild strawberries as an open question.

Strawberries from *F. vesca*, grown at Geneva, N.Y., were harvested in 1955 and stored at −18° for four months. These plants originated from one clone from East Malling, England. The thawed berries were pressed, and 300 ml. juice which had been saturated with sodium chloride was extracted with *n*-butanol; the extract was concentrated and the crude pigments precipitated with ether, yielding 0·6 gm. of red powder with an anthocyanin content of 7·5 per cent. The pigments were separated chromatographically by a procedure similar to that of Li and Wagenknecht[5]. The crude mixture, 120 mgm. in 0·75 ml. of the first aqueous phase plus 1·5 gm. silicic acid, was separated on a silicic acid column. The column was prepared from a slurry of 18·5 gm. silicic acid, 10·5 ml. of the first aqueous phase and excess organic phase. The first developing solvent was 250 ml. of the organic phase from *n*-butanol, acetic acid, chloroform and water (4 : 1 : 2·7 : 5 v/v), followed by 250 ml. of the organic phase of the above solvents in the ratio 4 : 1 : 2 : 5 v/v). 10-ml. fractions were collected and the optical density determined at 525 mμ. As Fig. 1 shows, resolution into four components was accomplished. The two major pigments account for 93 per cent of the light absorption of the crude pigment extract at 525 mμ. Recovery of the pigments from the column was quantitative.

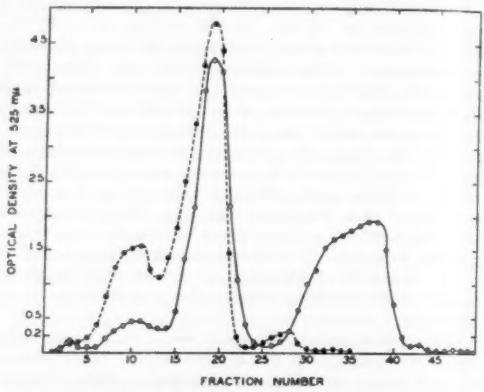

Fig. 1. Chromatographic separation of the anthocyanin pigments of wild and cultivated strawberries. ○——○, Pigments from *Fragaria vesca*, 120 mgm. crude pigments. ●——●, Pigments from cultivated strawberries, variety Culver, 40 mgm. crude pigments. In these solvent systems pelargonidin-3-monoglucoside, 1 mgm./10 ml., had an optical density of 4·38 and cyanidin-3-monoglucoside, 1 mgm./10 ml., had an optical density of 4·10 at 525 mμ

Fractions 14–26, band III, from two experiments were combined, the solvent evaporated and the residue converted to a crystalline picrate by treatment with aqueous picric acid. Recrystallization from water and conversion to the chloride yielded 4·0 mgm. of chromatographically homogeneous material; R_F 0·40, on Whatman No. 1 paper and the solvent system *n*-butanol, acetic acid and water (4 : 1 : 5)[6]. A mixture of this material and authentic pelargonidin-3-monoglucoside yielded only one band on the silicic acid column, and only one spot on paper chromatograms with the above solvent system. The absorption spectra of band III and pelargonidin-3-monoglucoside in acidified ethanol also were identical. Acid hydrolysis of the pigment from band III yielded a crystalline anthocyanidin which was shown to be indistinguishable from pelargonidin chloride by co-chromatograming the aglycones (R_F 0·81 with *n*-butanol saturated with 2 *N* hydrochloric acid), by comparison of their absorption spectra and by the usual colour tests. Chromatography with water-saturated phenol showed the sugar moiety to be indistinguishable from glucose, R_F 0·41, but readily separable from galactose, R_F 0·46. By analogous procedures the pigment from band IV (fractions 27–46) was shown to be indistinguishable from cyanidin-

3-monoglucoside, R_F 0·32, and its hydrolysis products from cyanidin, R_F 0·68, and glucose.

On the basis of this evidence, it is suggested that the major pigments of the fruit of *F. vesca* are pelargonidin-3-monoglucoside and cyanidin-3-monoglucoside. In the fruits we examined, these pigments were present in a 1 : 1 ratio in wild strawberries, and 1 : 0·05 (pelargonidin-3-monoglucoside to cyanidin-3-monoglucoside) in cultivated strawberries. Thus, the major difference in the pigment composition of wild and cultivated strawberries appears to be in the ratio of pelargonidin to cyanidin glucosides.

Incidental to this study, evidence was obtained for the presence of another anthocyanin, band II, fractions 7–12. This may be a second pelargonidin derivative since it has the same absorption spectrum as pelargonidin-3-monoglucoside, but can be separated from it on the silicic acid column. This material was absent in a pelargonidin-3-monoglucoside sample which had been isolated from cultivated strawberries and purified by recrystallization of its picrate[1]. The substance accounts for 6·5 and 21 per cent of the absorption at 525 mμ of the *n*-butanol extracts from wild and cultivated strawberries respectively. Band I, fraction 3, from the wild strawberries appears to be an anthocyanidin.

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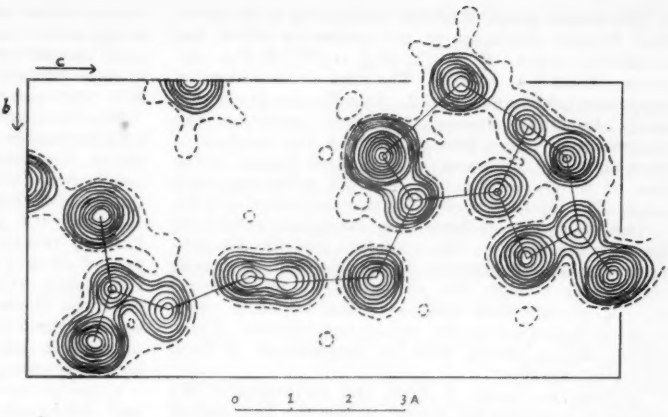

Fig. 2. Electron density projection on (100). Contours at intervals of one electron per A.^{2}, except for sulphur atom, where intervals are two electrons per A.^{2} after the seven-electron line. The two-electron line is broken

Crystal Structure of Biotin

BIOTIN (vitamin H) is a substance of considerable biological interest. It has been found to have the structural formula[1] shown in Fig. 1; but chemical investigations have not elucidated with certainty the configuration about the three asymmetric carbon atoms.

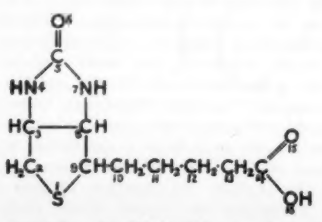

Fig. 1. Structural formula of biotin (atoms numbered arbitrarily)

Crystals of biotin were found to be orthorhombic with unit-cell axes $a = 5{\cdot}19$ A., $b = 10{\cdot}33$ A., $c = 21{\cdot}00$ A., in good agreement with values previously reported by Fankuchen[2] and Crocombe (unpublished work). The density of the crystals, as found by flotation in a chloroform–benzene mixture, is 1·42 gm./cm.^{3}, necessitating the presence of four molecules of biotin in the unit cell. An examination of the X-ray spectra for systematic absences showed the space group to be $P2_12_12_1$.

Equi-inclination Weissenberg photographs were taken about the *a*- and *b*-axes up to the third and seventh reciprocal-lattice layers respectively. Some 70 per cent of the spectra falling within the sphere of reflexion for copper radiation were actually recorded, and a visual estimation made of their intensities.

As a first attempt at structure analysis, the Patterson projections along the *a*- and *b*-axes were calculated. However, in view of the large number of interatomic vectors arising from the 16 atoms (other than hydrogen) in the asymmetric unit, their interpretation proved very difficult, and it was not found possible to locate even the sulphur atom unequivocally. Seven sections of the three-dimensional Patterson function were then evaluated. These were at $u = 0, \frac{1}{4}, \frac{1}{2}$; $v = 0, \frac{1}{2}$; $w = 0, \frac{1}{2}$ (where u, v, w are expressed as fractions of the unit-cell axes a, b, c). The position of the sulphur atom was now easily found from an examination of the three Harker sections ($u = \frac{1}{4}$, $v = \frac{1}{2}$, $w = \frac{1}{2}$), and this was used to produce superposition maps from the Patterson projections by the method of Buerger[3]. Though even the *bc* Buerger map was not sufficiently well defined to enable the location of individual atomic positions, it gave a general outline of the shape of the molecule and proved a valuable guide during the subsequent analysis of the three-dimensional Patterson diagram. Because of the short *a*-axis and the fact that the Patterson diagram was not sharpened, all the sixty relatively heavy peaks corresponding to vectors between the sulphur and the other atoms in the molecule were in fact recorded on one of the sections $u = 0$, $\frac{1}{4}$ or $\frac{1}{2}$ (though several were very small and poorly resolved). A systematic correlation of these peaks (four for each atom) enabled a satisfactory trial structure to be obtained.

The *a*-axis projection was refined by a series of four Fourier syntheses in the course of which the reliability index, $R = (\Sigma \|F_o| - |F^c\|/\Sigma|F_o|$, decreased from 0·41 to 0·20. The final electron density projection is shown in Fig. 2. As a Fourier projection along the *b*-axis showed very poor resolution, the *x*-parameters alone were refined by the method of least squares. This was done in three stages, in the last of which all the observed *h0l* reflexions were used. The final value of *R* for this projection is 0·23.

The analysis confirms the accepted structural formula for biotin. The molecule has the *cis* configuration at the junction of the two five-membered rings, and though the configuration about bond C_8—C_9 is somewhat staggered, the aliphatic chain is *cis* with respect to the ureido ring system. These results are in accord with the suggestions of Grob and von Sprecher[4].

Within the limits of error, the six atoms of the ureido ring system are planar, as are the four carbon atoms of the adjacent ring; the two planes making an angle of approximately 120°. The sulphur atom lies 0·75 A. off the second plane, thus giving the ringed portion of the molecule a boat-shaped configuration. Whereas the four carbon atoms in the aliphatic chain follow approximately the normal planar zigzag configuration, the bond C_9—C_{10}, which links the chain to the ring system, does not conform to this pattern and consequently the molecule is considerably elongated. Hydrogen bonds O_6—O_{16}, O_{15}—N_4 and O_{15}—N_7 serve to bind all the molecules in the crystal together.

A further refinement of the structure using the full three-dimensional data is now in progress, and when this is completed a more detailed account of this work will be published elsewhere.

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Surface Tension as the Cause of Bénard Cells and Surface Deformation in a Liquid Film

In 1900, Bénard[1] described his observations of a cellular deformation produced on the free surface of a liquid film the bottom surface of which (in contact with a floor) was uniformly heated and hotter than its top surface. He also observed a cellular flow associated with the deformation. These studies were made on films of thicknesses in the range 0·5–1·0 mm.

Rayleigh[2] and others analysed this phenomenon as an instability due to the density increasing from bottom to top. They obtained a critical film thickness below which there is stability.

This explanation in terms of density variation may be sufficient in the case of films thicker than about 1 mm. or when the liquid film has no free surface. Indeed, experimental investigations by Schmidt and Milverton[3] reveal a cellular motion in a liquid film bounded by horizontal plates, when the bottom plate is hotter than the top plate, that is, in agreement with the analyses. However, Bénard cells, specifically defined here as the hexagonal cells in films (thinner than about 1 mm.) with a free surface, may not be due to convective instability.

We have carried out the following experiments with a number of liquids. Bénard cells were established, for example, in a hydrocarbon liquid. A needle point was wetted with a silicone insoluble in the hydrocarbon. The needle point was then made to touch the surface of the hydrocarbon film exhibiting Bénard cells. A skin or layer was thereby floated off and the effects observed as it spread over the surface. Wherever and as soon as the layer passed over the Bénard cell, the surface deformation disappeared and the flow stopped. Clearly the variation of vertical density could not be affected so rapidly by the covering by the layer.

Consider now that both the Bénard cell motion and deformation are produced by variations in the surface tension; which are in turn due to variations in temperature. We may then apply the work of Hershey[4], who analysed the flow and the deformation produced by a uniform surface stress arising from a surface tension gradient (due to a temperature gradient). Hershey also observed that the deformation caused by a local cooling disappeared when an insoluble monolayer covered it, explaining that the monolayer "takes up the tangential stress". Hershey's analysis can be extended, for example, to account for Bénard's observation that the colder parts of the surface are the higher parts. On the other hand, Jeffreys[5] predicted, on the basis of free convection, that the hotter part should instead be the higher part.

I have therefore carried out the following experiments. Bénard cells were first produced and then removed by covering with a monolayer. Then the thickness of the liquid film (covered by a monofilm) was increased until cellular surface deformation and circulation could again be seen. The thickness at which this occurred was 2 mm., which is, in this case, about the predicted critical depth for the onset of convective instability. The cellular deformation that occurred at 2 mm. did not have as regular a pattern as the hexagonal Bénard cells previously obtained with a clean liquid surface. This irregular pattern occurred both when the surface was clean and when it was covered with the monofilm. However, decreasing the temperature at the base of a film showing an irregular pattern caused the production of the typical hexagonal Bénard pattern.

Bénard cells were observed, during these experiments, for a thickness as small as 50 microns. At that thickness, there was no indication that the limiting thickness, below which there would be stability, had been reached. This thickness is at least an order of magnitude smaller than the predicted critical depth for convective instability.

Finally, I carried out an experiment in which a liquid film (about 0·8 mm. thick) with a free surface was cooled at its base and should therefore have been convectively stable. Nevertheless, cellular patterns were observed, the more regular patterns having the appearance of Bénard cells. It would therefore appear that the instability causing Bénard cells is quite different from the Rayleigh instability.

Convection has also been considered, erroneously, in another case. Heintz[6] made an experimental study of the surface deformation caused by a temperature variation in liquid films (0·3–1·0 mm. thick). In a qualitative way he ascribed the effect

to convection. I have obtained similar experimental refutation as in the case of the Bénard cells, again using a floating layer. The importance of considering the role of surface tension in this phenomenon is illustrated by the failure of Heintz to obtain the effect he describes in water. However, whenever sufficient care was used so as not to contaminate the water surface, we obtained the effect.

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A New Uncertainty Relation

ONE of the consequences of the introduction of a geometry of four dimensions as a basis of physical theory has been to reveal relations between certain quantities which had previously appeared to differ fundamentally in character, the simplest being the relation between space and time. In geometries which introduce new parameters or new dimensions, a similar unexpected unification may appear. This is particularly the case in the theory based upon the use of projective geometry associated with the names of Veblen and Hoffmann, and with the five-dimensional theory introduced by Kaluza. It is necessary to express any results obtained in this way in a form which satisfies the requirements of relativistic invariance; but the development of both these theories has proceeded in such a way as to make this possible.

In this framework the principles of conservation of energy and momentum are seen to be parts of a wider principle which embraces that of electric charge also. It was suggested also that an additional condition should be added to the relations $\int pdq = nh$ of the old quantum theory, and this was interpreted as expressing the quantization of electric charge[1]. In the light of a recent discussion[2] concerning the four-dimensional interpretation of such results, a new uncertainty relation is suggested. To the four familiar conditions it seems natural to add $\Delta m_0 \Delta\tau \sim \hbar/c^2$. The interpretation would be that in order to measure a rest-mass m_0 to the accuracy Δm_0, an interval of proper time $\Delta\tau$ must elapse, the two quantities Δm_0 and $\Delta\tau$ satisfying the above inequality.

This condition is also suggested by a work by K. H. Tzou[3] on the relativistic form of Heisenberg's quantum equation, in which the quantities $m_0 c$ and $c\tau$ occur in such a way as to suggest a pair of conjugate quantities.

An application of it would be to cases of the transformation of nuclear particles in which the time of decay, being the time available for observation, would limit the observable change of rest mass.

At first sight the relation appears to be a special case of the energy relation:

$$\Delta E \, \Delta t \sim \hbar$$

which for a particle of mass m in the absence of a field of force becomes,

$$\Delta m \, \Delta t \sim \hbar/c^2$$

This is usually applied to cases where the rest mass does not change. If it be assumed that it applies to the case of a particle which changes its rest mass while at rest, Δm is a change of rest mass and Δt a change of proper time.

The two conditions are the same in this case. Prof. P. Caldirola[4] has applied the energy relation in this way. Adopting the view that a μ-meson is an electron in a higher energy state, he points out that

$$(\mu_0 - m_0) \, \Delta t \sim \hbar/c^2$$

μ_0 and m_0 being the respective rest masses, and discusses the significance of the relation on the assumption that a minimum interval of time Δt exists. But the relation proposed here is not essentially an energy relation, and its application is not restricted to cases where the particle under consideration is at rest. When no restriction is placed upon the motion of the particle, the two conditions do not coincide. It is suggested that the rest mass condition is an independent one.

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Fixation of Carbon Dioxide into the Carboxyl Carbon of Glycine

IT has been observed that carbon dioxide is a precursor to the carboxyl carbon of glycine in incubations with a hen-oviduct mince. Carbon 2 of the glycine is completely unlabelled when determined as the formaldehyde dimedone complex obtained after ninhydrin degradation. Carboxyl-labelled acetate is also formed in this system from carbon dioxide[1]. Acetate 1,2-^{14}C, however, was found to be a poor precursor to glycine, although it was converted to glutamic acid much more efficiently than carbon dioxide.

These observations appear to diminish the likelihood that carbon dioxide is entering glycine through acetyl coenzyme A or acetate directly. There appear two possible explanations. Glycine may be formed directly from an activated acetyl compound arising from the carbon dioxide fixation previous to acetyl coenzyme A, or carbon dioxide may be fixed independently to two distinct acceptors, one of which yields acetate and the other glycine.

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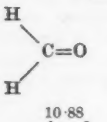
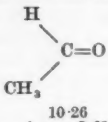
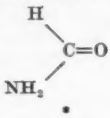
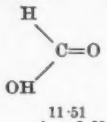
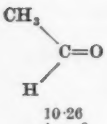
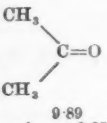
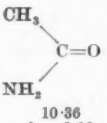
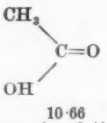
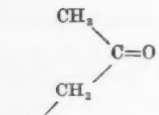
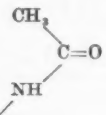
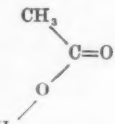
Ionization Potentials of Carbonyl Molecules

The first ionization energies of carbonyl molecules are largely determined by the non-bonding electrons at the oxygen atom of the carbonyl group. If electric charge flows from the other part of the molecule into the oxygen, the effective electro-negativity of that atom will become decreased, and hence the ionization potential of the molecule will be reduced[1]. From this point of view, it is expected that the magnitude of the ionization potential will serve as a clue to the state of electron transmission in a carbonyl molecule.

In the present work, measurements were made of the first ionization potentials by use of a Hagstrum type mass-spectrometer[2]. The evaluation of the potentials was made according to the critical slope method[3], argon being employed as the calibration gas. The results are recorded in Table 1.

Table 1. First Ionization Potentials (eV.)

			
10·88 Δ = 0	10·26 Δ = −0·62	* Δ = ?	11·51 Δ = 0·63
			
10·26 Δ = 0	9·89 Δ = −0·37	10·36 Δ = 0·10	10·66 Δ = 0·40
			
9·74 Δ = −0·52	10·21 Δ = −0·05	10·51 Δ = 0·25	

* No measurement was possible on account of the scarcity of molecular ion formed.

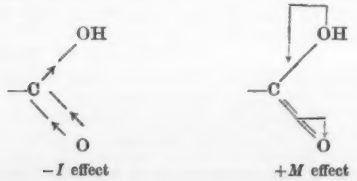
It will be seen that the replacement of a hydrogen atom in H·CHO and H·COCH$_3$ by CH$_3$ or CH$_2$·CH$_3$ lowers the potential values, while replacement by NH$_2$, OH or OCH$_3$ tends to raise them. This trend in the potentials may be accounted for if the inductive mechanism is taken into consideration. That is, the Ingold's sequence[4] of $-I$ effect is:

(*a*) OH > NH$_2$ > H; OCH$_3$ > NHCH$_3$ > H

and that of the $+I$ effect is

(*b*) CH$_2$(CH$_3$) > CH$_3$ > H

This is rather surprising, since the mesomeric effect of the group (*a*) which counteracts the $-I$ effect is supposed to be more important. Both effects are illustrated for the group —CO·OH.



We thank Prof. C. A. Coulson for his interest in this work.

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April 4.

[1] Coulson, C. A., "Valence", 186 (Oxford, 1952).
[2] Omura, I., Higasi, K., and Baba, H., *Bull. Chem. Soc. Japan* (in the press).
[3] Honig, R. E., *J. Chem. Phys.*, **16**, 105 (1948).
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Effects of Pressure on the Superconducting Transition in Tin

Recently, Muench[1] has investigated the displacement of the critical temperatures T_c of tin and indium produced by pressures of up to 100 atmospheres (obtained by compressing helium gas), and by a pressure of 1,900 atmospheres (obtained by the ice-expansion bomb technique); and he has measured the value of $(\Delta H_c/\Delta p)_T$, where H_c denotes the critical magnetic field and p the pressure, at temperatures between 1° K. and T_c for each of these metals. These experiments are important in that they provide the most complete data yet obtained on the effects of pressure on the superconducting transition.

In analysing his results, however, Muench assumed that $(\partial H_c/\partial p)_T$ is independent of pressure. There is no satisfactory experimental evidence in support of this hypothesis: the earlier work of Kan, Sudovstov and Lasarew[2] at pressures of 1,350 and 1,700 atmospheres was not sufficiently accurate to allow one to deduce that $\partial^2 H_c/\partial p^2$ is negligibly small, while Muench's own work only suffices to show that, at a given temperature, H_c is a linear function of pressure within experimental error over the very restricted range between 0 and 100 atmospheres. Indeed, a review of experimental results concerning second-order partial derivatives shows that the evidence in favour of $(\partial H_c/\partial p)_T$ being substantially independent of pressure is much less convincing than is that in favour of $(\partial T_c/\partial p)_H$ being substantially independent of pressure. Chester and Jones[3], for example, have succeeded in extending almost tenfold the pressure-range over which the superconducting transition in tin has been observed without thereby being able to detect lack of linearity in the relationship between T_c and p; and, although their accuracy was not of a high order at a pressure of 17,500 atmospheres, it is significant that, within experimental error, these results conform to the same straight line as do the less extensive measurements of Kan, Sudovstov and Lasarew.

By making use of a consistency relation between the first- and second-order partial derivatives which holds at any typical point on the H_c—T—p surface separating the superconducting and the normal phases, it is possible to devise an iterative computational procedure whereby the Muench assumption of pressure-independence of $(\partial H_c/\partial p)_T$ can be dispensed with, and values for $\partial^2 H_c/\partial p^2$ can be deduced from his data. Preliminary calculations made on this basis for the case of tin show that $\partial^2 H_c/\partial p^2 = -8 \times 10^{-20}$ gauss dyne^{-2} cm.^{4} at the zero-pressure critical temperature of 3·73° K. The value of $\partial^2 H_c/\partial p^2$ increases as the temperature is reduced, becomes zero at about

2·4° K., and remains positive between this latter temperature and 1° K. The work so far completed suggests that $\partial^2 H_c/\partial p^2$ may become as large as 5×10^{-19} gauss dyne^{-2} cm.^{4} at the lower end of the temperature-range covered by Muench's experiments.

From the zero-pressure values computed for $(\partial H_c/\partial p)_T$ it is possible to deduce that, for any fixed temperature in the neighbourhood of T_c, it would be necessary to apply a pressure of at least 2,000 atmospheres to tin in order to produce an overall departure from linearity of 1 per cent in the relationship between H_c and p. It would, of course, not be easy to check experimentally such a small deviation from linearity, because of the difficulty of measuring pressures of this order of magnitude with adequate precision.

A fuller account of the work will be presented in due course.

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Jesus College,
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May 7.

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[2] Kan, L. S., Sudovstov, A. I., and Lasarew, B. G., *J. Exp. Theor. Phys. U.S.S.R.*, **18**, 825 (1948).
[3] Chester, P. F., and Jones, G. O., *Phil. Mag.*, **44**, 1281 (1953).

Interior Deformation Markings in Copper Fatigue Specimens

A METALLOGRAPHIC investigation of several fractured low-stress rotating cantilever specimens of low-oxygen copper was carried out, employing various etchants, in an attempt to detect metallographically any evidence of deformation in the interior. Average composition of the specimens was 0·0027 per cent oxygen, 0·0007 per cent nitrogen, 0·8 c.c./100 gm. hydrogen, 99·95 per cent copper.

Wadsworth and Thompson[1] have electropolished copper fatigue specimens at various stages during the fatigue life, and have shown that, although most slip bands are removed by polishing off 2μ, some slip bands persist, and that it is from these "persistent slip bands" that fatigue cracks ultimately develop. Their observations have been restricted to the surface of specimens.

In the present experiments, the specimens were copper plated, sectioned diametrically by a slitting wheel flooded with coolant, polished mechanically and finally electrolytically polished in orthophosphoric acid. The sections were then etched in each of ten etchants in turn, an intermediate light polish being given to remove completely the previous etch.

The etchants employed were those listed by Samuels[2] as capable of developing deformation markings in copper and copper-base alloys. Briefly, they are:

(1)	Potassium dichromate	5 gm.
	Sulphuric acid (conc.)	8 ml.
	Water	50 ml.
	Hydrochloric acid (conc.)	2 ml./50 ml.
(2)	Ammonium hydroxide	1 vol.
	Hydrogen peroxide (3 per cent)	2 vol.
	Water	2 vol.
(3)	Ferric chloride	5 gm.
	Hydrochloric acid (conc.)	10 ml.
	Water	100 ml.
(4)	10 per cent phosphoric acid at 90° C.	
(5)	10 per cent ammonium persulphate at 50–60° C.	
(6)	10 per cent cupric chloride plus ammonia to alkalinity.	
(7)	Electrodes of standard electropolishing bath short-circuited at end of polishing cycle.	
(8)	Washed and dried specimen immersed in standard orthophosphoric acid polishing bath at 0·6–0·8 V.	
(9)	0·25 per cent sodium thiosulphate solution at 3·5 amp./dm.^{2}.	
(10)	0·5 per cent sodium thiosulphate solution at 1 amp./dm.^{2}.	

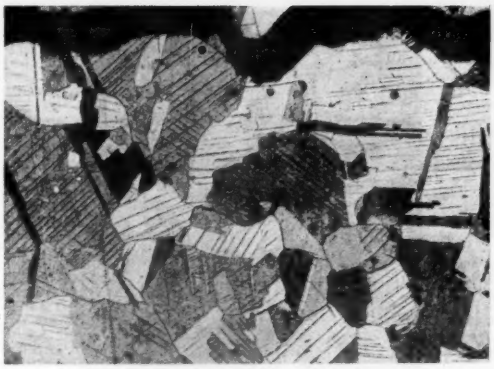

Fig. 1. Microstructure of rotating-cantilever specimen of copper, taken at the main fracture (black band) and on a section approximately 1 mm. under the original surface. Specimen fractured at 14,000 lb./sq. in. after 632,400 cycles at 21 c./min. Specimen axis vertical. Etched with acid ferric chloride. × 100

The results of using each of these etchants in turn showed that: (*a*) etchants (1), (4), (7), (9) and (10) produced a normal etch by developing grain boundaries, twin boundaries and oriented lustre in varying degrees; (*b*) etchants (2), (3), (5) (6) and (8) produced a similar etch, but in all cases the grains showed striations.

An area was selected on a specimen exhibiting these striations, and photographs were taken of this area after etching with each of the etchants in group (*b*) above. The striations observed were the same with each of these etchants, and simply varied in intensity. It was possible to arrange these etchants in order of decreasing effectiveness in developing striations, as follows: acid ferric chloride, cupric ammonium chloride, ammonium persulphate, electrolytic polishing cell etch, ammonium hydroxide – hydrogen peroxide.

An example of the striations is shown in Fig. 1. The area illustrated includes the main crack (black irregular band), and is approximately 1 mm. under the original curved surface of the specimen. This specimen had fractured at 14,000 lb./sq. in. after 632,400 c./min. Striations were observed in the area up to 5 mm. on either side of the main crack.

It will be noted that the striations bear no relation to the specimen axis, but are definitely crystallographic in nature, because: (i) they change direction when crossing an annealing twin; (ii) one or more parallel sets may be present in one crystal; (iii) they are essentially straight.

Samuels[2] has classified the deformation marks produced by compression in copper and copper-base alloys into four types, based on differences in visual appearance and on the orientation of the marks relative to the axis of compression. The striations shown in Fig. 1 do not correspond to any of these four types, and thus presumably indicate that deformation has occurred in the fatigue specimens in a different mode from that in compression.

The acid ferric chloride etch was used on specimens of the same copper, initially annealed and then deformed in tension to 1, 2, 4, 8, 10, 20, 30 and 40 per cent elongation, and also on a specimen cut from the compression side of a bent bar. Again in no case did the striations shown in Fig. 1 correspond to the deformation marks in the tension and compression specimens, a further indication that deformation has

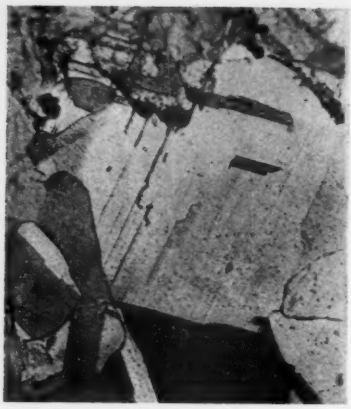

Fig. 2. Cross-section of the surface of a machined rotating-cantilever specimen of copper, showing short fatigue cracks running along striations. Specimen had fractured completely some 3 mm. from this point at 16,000 lb./sq. in. after 476,000 cycles at 170 c./min. Specimen axis horizontal. Etched with acid ferric chloride. × 370

occurred in the fatigue specimens in a different mode from that in tension and compression.

The striations are not produced by the sectioning technique, since they may also be readily developed on the polished surface of a similar fatigue specimen, free of striations before the fatigue test. Neither are the striations produced by gradual application of the stress during loading, since they do not develop until a later stage in the fatigue life.

Fig. 2 shows small cracks in a surface crystal of a low-stress rotating-cantilever specimen. The cracks run along the striations revealed by etching, indicating that these, or the mode of deformation which results in their development, may play an important part in the formation of fatigue cracks. Similar striations have also been observed in fractured low-stress push–pull specimens of copper. Thus, they appear to be characteristic of low-stress fatigue-deformation in copper. Experiments concerning the variations in intensity of the striations due to stress and to testing frequency are to be described shortly. Also, the nature of the markings is being investigated by annealing experiments and by electron microscope investigations.

This work forms part of the research programme on fatigue at the Aeronautical Research Laboratories, Department of Supply, Melbourne. Acknowledgment is made to the Chief Scientist, Department of Supply, for permission to publish this communication.

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Melbourne. Feb. 29.

[1] Wadsworth, N. J., and Thompson, N., *Phil. Mag.*, **45** (7), 223 (1954).
[2] Samuels, L. E., *J. Inst. Metals*, **83**, 359 (1955).

Mechanism of the Electrolytic Deposition of Titanium

One of the commercial methods of manufacturing pure titanium metal involves the high-temperature electrolysis of either K_2TiF_6, $TiCl_4$ or $TiCl_3$ in a molten alkali halide eutectic. Several such processes have been in operation for some time, and certain details of the preparative techniques have been published[1]. The mechanism of these electrolytic methods has, however, remained in doubt. Of the two possibilities, (1) primary deposition of a titanium ion, complex or otherwise, on to a suitable cathode, or (2) secondary deposition where the titanium species are reduced by electrolytically produced alkali metal, the latter has seemed more probable because of the amorphous nature of the resultant titanium. It is true that fairly large dendritic crystals of titanium are produced during the electrolysis, but such dendrites are also found in the commercial preparation of titanium where $TiCl_4$ is reduced with liquid sodium. The current–voltage relations observed during electrolysis are also in keeping with a predominantly secondary process.

Recently, we have obtained direct evidence that the metal is finally produced by a secondary process; but, depending on the starting materials, this can be preceded by one or more primary steps. Using the gas-flushed tungsten micro-electrode, recently developed by Inman[2], polarographic analyses have been made of solutions of K_2TiF_6, $TiCl_4$, $TiCl_3$ and $TiCl_2$ in the LiCl—KCl eutectic at temperatures between 380° and 550° C. Excellent reversible polarograms have been obtained for the primary reduction of $TiCl_3$ to $TiCl_2$, the half-wave potential with respect to platinum being −2·58 V. at 400° C., that for the decomposition of the eutectic being −2·79 V. The wave-height is strictly proportional to the concentration of $TiCl_3$ up to 0·01 weight per cent corresponding to ~ 200 μamp., the highest current measurable with the recorder. The log $i/i_d - i$ against E relation indicates a one-electron reduction step. That the reduction is to $TiCl_2$ and not to titanium metal is also evident when, after complete reduction, the reverse process is clearly indicated from the corresponding anodic polarogram.

$TiCl_4$ gives a cathodic wave at $E_{1/2} = -1{\cdot}4$ V. at 400° C., although its form is distorted because of the difficulty in maintaining any concentration of $TiCl_4$ in the melt.

Neither $TiCl_2$ nor K_2TiF_6 gives a detectable cathodic wave or limiting current. A finite current only flows when the applied voltage exceeds −2·79 at 400° C., that is, the decomposition potential of the pure eutectic. It is therefore clear that K_2TiF_6 and $TiCl_2$, in this melt at least, can only be secondarily reduced to titanium by chemical reaction with alkali metal.

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[1] Cordner and Worner, *Aust. J. App. Sci.*, **2**, 351 (1951). Worner, Wells and Worner, *J. Electrochem. Soc.*, **100**, 18 (1953). Bett, Hickman, Willis and Worner, Inst. Min. Metall. Symposium No. 21 (1956). Brenner and Senderoff, *J. Electrochem. Soc.*, **100**, 223C (1953). Titan Co., Inc., B.P. 682,919 (1952). Shawinigan Water-Power Co., B.P. 678,807 (1952). Smart (I.C.I.), B.P. 698,151 (1952). Drossbach, *Z. Elektrochem.*, **57**, 556 (1953). Steinberg, Siebert and Walner, *J. Electrochem. Soc.*, **101**, 63 (1954). Steinberg, Siebert, Coriton and Walner, *J. Electrochem. Soc.*, **102**, 332 (1955). Kawane, *J. Electrochem. Soc. (Japan)*, **22**, 662 (1954). Okada, Kawane and Takahashi, *Bull. Eng. Res. Inst. Kyoto Univ.*, **6**, 57 (1954).
[2] Hills and Inman (in preparation).

FORTHCOMING EVENTS

Tuesday, September 25

INSTITUTION OF CIVIL ENGINEERS (at Great George Street, Westminster, London, S.W.1), at 5.30 p.m.—Mr. F. R. Farmer: "The Problem of Liquid and Gaseous Effluent Disposal at Windscale".

SOCIETY OF INSTRUMENT TECHNOLOGY (at Manson House, Portland Place, London, W.1), at 6 p.m.—Presentation of Bowen Prize by Mr. G. A. Whipple. Dr. E. A. Spencer and Mr. A. T. J. Hayward: "The Accurate Calibration of Flowmeters".

Wednesday, September 26

BRITISH INSTITUTION OF RADIO ENGINEERS (at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street London, W.C.1), at 6.30 p.m.—Dr. H. W. Loeb: "Some Aspect of Transistor Progress".

Friday, September 28

ASSOCIATION OF APPLIED BIOLOGISTS (in the Mining Lecture Theatre, Royal School of Mines, Prince Consort Road, London, S.W.7), at 10.30 a.m.—Symposium on "The Use of Antibiotics Against Plant Diseases".

APPOINTMENTS VACANT

APPLICATIONS are invited for the following appointments on or before the dates mentioned:

LECTURER or ASSISTANT, Grade B (with special qualifications in plant physiology and preferably teaching and research experience) IN BOTANY—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3 (September 28).

BIOCHEMIST, Senior Grade (with a first- or second-class honours degree), for duties which include both routine hospital biochemistry and work connected with the investigations into the uses of radioactive isotopes in medicine—The Secretary, Liverpool Radium Institute Management Committee, 1 Myrtle Street, Liverpool 7 (September 29).

CHEMIST (with a first- or good second-class honours degree or equivalent qualification and at least three years experience, and preferably a knowledge of liquid fuels and lubricants) in the Central Laboratory, Chiswick—The Recruitment and Training Officer (F/EV. 597), London Transport, 55 Broadway, London, S.W.1 (September 29).

DEMONSTRATOR (with a first- or second-class degree in chemistry) IN THE DEPARTMENT OF ORGANIC CHEMISTRY—The Registrar, The University, Liverpool (September 29).

ENTOMOLOGISTS (with at least a second-class honours degree in entomology, and preferably a knowledge of botany and plant ecology techniques) IN THE DEPARTMENT OF TSETSE AND TRYPANOSOMIASIS CONTROL AND RECLAMATION, Federal Ministry of Agriculture, Federation of Rhodesia and Nyasaland, for duties which will include field studies and surveys in tsetse fly areas as a preliminary to land reclamation—The Public Service Attaché, Rhodesia House, 429 Strand, London, W.C.2 (September 29).

PHYSICS GRADUATE IN THE DEPARTMENT OF RADIOTHERAPY, for work which will include developments connected with rotation therapy, multicurie cobalt units and the use of radioactive isotopes—The Assistant Administrator, Churchill Hospital, Oxford (September 29).

SCIENTIFIC OFFICER (honours graduate) IN THE PLANT PATHOLOGY SECTION to work mainly on seed-borne diseases—The Secretary, National Vegetable Research Station, Wellesbourne, Warwick (September 29).

ASSISTANT LECTURER or LECTURER (with special qualifications in palæontology) IN GEOLOGY—The Registrar, King's College, Strand, London, W.C.2 (October 1).

LECTURER (preferably with either (*a*) knowledge and experience of servo mechanisms or process control; or (*b*) research experience in some branch of electronics) IN APPLIED ELECTRICITY—The Secretary and Registrar, University College of North Wales, Bangor (October 1).

ASSISTANT (preferably with a special interest in vertebrates) IN ZOOLOGY—The Secretary of University Court, The University, Glasgow (October 5).

LECTURER IN THE DEPARTMENT OF METALLURGY—The Registrar, The University, Liverpool (October 6).

RESEARCH ASSISTANT (with a first- or second-class honours degree in chemistry) IN THE CHEMISTRY DEPARTMENT—The Principal, Derby and District College of Technology, Normanton Road, Derby (October 6).

ASSISTANT LECTURER (Grade III) or DEMONSTRATOR IN PHARMACOLOGY—The Registrar, The University, Bristol (October 8).

STAFF TUTOR IN THE DEPARTMENT OF ADULT EDUCATION—The Registrar, University College, Leicester (October 13).

VETERINARY BACTERIOLOGIST (with a university degree in science or veterinary science, with honours, together with postgraduate research experience in bacteriology, or equivalent qualifications) IN THE DIVISION OF ANIMAL HEALTH AND PRODUCTION, Commonwealth Scientific and Industrial Research Organization, Sydney, to participate in a research programme on the bacteriology of footrot and foot abscess, including studies on the pathogenesis and immunology of these diseases; investigations on mycotic dermatitis and fleece rot of sheep will also be undertaken—Chief Scientific Liaison Officer, Australian Scientific Liaison Office, Africa House, Kingsway, London, W.C.2, quoting Appointment No. 202/115 (October 13).

LECTURER IN INORGANIC CHEMISTRY at the University College of Rhodesia and Nyasaland—The Secretary, Inter-University Council for Higher Education Overseas, 29 Woburn Square, London, W.C.1 (October 15).

LECTURER (with a good honours degree, including heavy current subjects) IN ELECTRICAL ENGINEERING—The Secretary and Registrar, The University, Southampton (October 15).

LECTURER (CHEMIST) IN THE DEPARTMENT OF MUNICIPAL ENGINEERING—The Registrar, College of Science and Technology, Manchester 1 (October 20).

DIRECTOR OF THE COMPUTING UNIT—The Secretary of Faculties, University Registry, Oxford (October 30).

LECTURER or SENIOR LECTURER IN FLUID DYNAMICS at the University of Tasmania—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Australia, October 31).

PROFESSOR (with high academic qualifications and considerable experience in research or development work in metallurgy or generally in the science of materials) OF MATERIALS AND METALLURGY—The Principal, College of Aeronautics, Cranfield, Bletchley, Bucks (October 31).

READER IN MARINE BIOLOGY in the Department of Biology, University of Hong Kong—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (Hong Kong, October 31).

SENIOR LECTURER IN MINERAL ENGINEERING at the University of Otago, Dunedin, New Zealand—The Secretary, Association of Universities of the British Commonwealth, 36 Gordon Square, London, W.C.1 (New Zealand, October 31).

DIRECTOR OF THE MEDICAL PHYSICS UNIT—The Secretary to the University, Old College, South Bridge, Edinburgh (November 1).

AGRONOMIST (preferably with a good honours degree and practical experience) AT GAMBIA RICE FARM (H.M. Oversea Civil Service), to undertake experiments in the cultivation of irrigated rice and of alternative crops suitable for dry-season cultivation under irrigation—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/12/08.

ASSISTANT CONSERVATOR OF FORESTS (with a university degree in forestry or a degree in natural science supplemented by at least one years training in forestry) in Tanganyika (H.M. Oversea Civil Service)—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.61/8/01.

ASSISTANT (Grade B) IN THE DEPARTMENT OF PHYSICS—The Clerk to the Governors, Chelsea Polytechnic, Manresa Road, London, S.W.3.

ASSISTANT LECTURER IN AGRICULTURAL ZOOLOGY—The Registrar, The University, Nottingham.

BACTERIOLOGIST, Scientific Officer or Senior Scientific Officer grade, to assist in work on the nutritional significance of micro-organisms of the digestive tract—The Secretary, Rowett Research Institute, Bucksburn, Aberdeenshire.

BLEACHERS' ASSOCIATION LIMITED FELLOW IN THE DEPARTMENT OF TEXTILE INDUSTRIES, for research on cellulosic fibres—The Registrar, The University, Leeds 2.

GRADUATE IN BIOLOGICAL SCIENCE, to assist in research on mass culture of marine algae—The Professor of Zoology, The University, Southampton.

LABORATORY TECHNICIAN (with experience and skill in general bacteriological methods, and preferably special experience in methods applicable to studies on viruses and tissue culture work)—The Secretary, The Research Institute (Animal Virus Diseases), Pirbright, Surrey.

LECTURER or ASSISTANT LECTURER (Grade B) IN THE DEPARTMENT OF MATHEMATICS—The Secretary, Sir John Cass College, Jewry Street, London, E.C.3.

LECTURERS (with an honours degree) IN ELECTRICAL ENGINEERING, PHYSICS and MATHEMATICS—The Principal, Paisley Technical College, 28–40 George Street, Paisley.

LEVERHULME SENIOR RESEARCH FELLOW (preferably with experience of bio-assay or radioisotope techniques), to work on the effects of steroid hormones in ruminants, and in particular, to investigate the physiological bases for the improvement of growth-rate resulting from hormone treatment—The Registrar, The University, Nottingham.

PHYSICS TECHNICIAN (preferably with a knowledge of vacuum technique)—The Director, Radiobiological Research Unit, Medical Research Council, Atomic Energy Research Establishment, Harwell, Berks.

RECORDS OFFICER (with a university degree in natural science or agriculture or a related biological science, and preferably experience in publishing, collecting or abstracting scientific work) IN THE DEPARTMENT OF AGRICULTURE, Federation of Nigeria, to assist in the collection and dissemination of information on agricultural research within the Federation of Nigeria, and to assist in the preparation of scientific publications and memoranda—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.63/14/041.

RESEARCH OFFICER (CYTO-GENETICIST) (with a good honours degree and at least two years postgraduate experience in plant genetics, and preferably training and experience in cytology) with the East African Agriculture and Forestry Research Organization, Kenya, to undertake genetical studies of crop plants aimed at providing basic knowledge for the breeding of plants for disease resistance and other qualities—The Director of Recruitment, Colonial Office, London, S.W.1, quoting BCD.195/151/01.

RESEARCH WORKER (physics graduate), for investigations on physical properties of rubber-like materials—The Secretary, Research Association of British Rubber Manufacturers, Shawbury, Shrewsbury.

SCIENCE GRADUATE (metallurgy, chemistry) for administrative and technical duties—The Assay Master, Assay Office, Newhall Street, Birmingham 3.

SENIOR LABORATORY TECHNICIAN—The Secretary, Research Station, Long Ashton, Bristol.

SENIOR LECTURER (with a good honours degree and industrial or research experience) IN THE STRENGTH OF MATERIALS—The Secretary, The Royal Technical College, Glasgow.

SENIOR SCIENTIFIC OFFICER (with a first- or second-class honours degree in electrical engineering or physics, and three years postgraduate experience, and preferably some experience in any of the

following: (*a*) millimicrosecond pulse techniques, (*b*) weapon firing trials, or (*c*) the development of weapon test instruments) to lead a team responsible for the development trials of electrical and electronic equipment for use in weapons—The Senior Recruitment Officer, Atomic Weapons Research Establishment, Aldermaston, Berks, quoting Ref. A.1059/94.

Statistician (with at least a second-class honours degree and not less than two years postgraduate experience in the application of modern statistical procedures to biological experimentation) with the East African Agriculture and Forestry Research Organization, to take charge of the Statistical Section of the Organization, to study and to advise on the design of biological experiments, to advise on the procedures for the statistical analysis of results, and to collaborate in experiments to study sampling techniques, etc.—The Director of Recruitment, Colonial Office, Sanctuary Buildings, Great Smith Street, London, S.W.1, quoting Ref. BCD.195/151/05.

Technician in the Department of Geography—The Secretary, Bedford College (University of London), Regent's Park, London, N.W.1.

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